# INSTRUCTION MANUAL

FOR

# ONAN ELECTRIC GENERATING PLANTS

Series

# BH

Spec.

# L

Models

ALTERNATING CURRENT

DIRECT CURRENT

BATTERY CHARGERS

D. W. ONAN & SONS INC. MINNEAPOLIS 14, MINN.

# GENERAL INFORMATION

**THE PURPOSE OF THIS BOOK.** This instruction book is furnished so that the operator may learn of the characteristics of the plant. A thorough study of the book will help the operator to keep the plant in good operating condition so that it will give efficient service. An understanding of the plant will also assist the operator in determining the cause of trouble if it occurs.

**KEEP THIS BOOK HANDY.** Such simple mistakes as the use of improper oil, improper fuel, or the neglect of routine servicing msy result in fsilure of the plant at a time when it is urgently needed. It is suggested that this book be kept near the plant so that it may be referred to when necessary.

**SERVICE.** If trouble occurs and the operator is unable to determine the cause after a thorough study of this book, or if he is unable to determine what repair parts are required, needed information will be furnished upon request. When asking for information, be sure to state the Model, Serial, and Generator numbers of the plant. This information is absolutely necessary and may be obtained from name plates on the plant. Give all other available details.

## MANUFACTURER'S WARRANTY

The manufacturer warrants each new engine or electric plant to be free from defects in material and workmanship. Under normal use and service our obligation under this warranty is limited to the furnishing of any part without charge which, within ninety (90) days after delivery to the original user shall be returned to us or our authorized service station with transportation charges prepaid, and which our examination shall disclose to have been defective.

Our liability in case of defective workmanship, material or any costs incurred in remedying any claimed defective condition in any unit or such unit having been repaired, altered, or which installation and service recommendations have not been complied with, is limited strictly to the proper adjustment authorized by the factory.

This warranty does not include or cover standard accessories used, such as carburetors, magnetos, fuel pumps, etc., made by other manufscturers. Such accessories have separate warranties made by the respective manufacturers. Repair or exchange of such accessories will be made by us on the basis of such warranties.

This warranty is in lieu of all othet warranties expressed or implied.

**IMPORTANT--RETURN WARRANTY CARD ATTACHED TO PLANT.**

# TABLE OF CONTENTS

# LIST OF ILLUSTRATIONS

# PLANT RUNNING HOURS
# COMPARED TO AUTOMOBILE RUNNING MILES

The engine of your generating plant makes as many revolutions in one hour, as the average automobile engine does when the car travels a distance of 41 miles.

100 running hours time on a generating plant engine is equivalent in total RPM's to approximately 4100 running miles on an automobile.

However, do not conclude that the wear on the generating plant engine and the wear on the automobile engine would be the same. The generating plant engine is built much more ruggedly, (having larger main bearings, bigger oil capacity and has a heavier crankshaft proportionately per horsepower) than most automobile engines. Given the proper care and periodic servicing the generating plant engine will continue to give many more hours of efficient service than an automobile engine will after having been run the equivalent number of running miles.

Compare the running time of your generating plant engine with the number of miles traveled by an automobile. The oil in an auto is checked every one or two hundred miles (3 to 5 hrs. running time) and changed every 1000 to 1500 miles (28 to 42 hrs.) Whereas in a generating plant or stationary power engine, the oil should be checked every 6 to 8 running hours (250 to 350 miles) and changed every 50 to 100 operating hours (2000 to 4000 miles) depending on operating conditions.

About every 5,000 to 10,000 miles (120 to 250 hours), services have to be performed on an auto, such as checking ignition points, replacing spark plugs, condensers, etc. Similarly on your generating plant engine, these same services have to be performed periodically except the change period is reckoned in hours. 10,000 miles on an auto is equivalent to about 250 running hours on your plant engine.

To arrive at an approximate figure of comparative generating plant running hours as against automobile engine running miles, multiply the total number of running hours by 41 to find the equivalent of running miles on an automobile.

Your generating plant engine can "take it" and will give many hours of efficient performance provided it is serviced regularly.

Below is a chart showing the comparison between a generating plant engine running hours and an automobile running miles.

| | GENERATING PLANT RUNNING HOURS | AUTOMOBILE RUNNING MILES |
|---|---|---|
| DAILY AVERAGE | 1 Hr. | 41 Miles |
| | 4 Hrs. | 164 " |
| | 6 " | 246 " |
| | 8 " | 328 " |
| WEEKLY AVERAGE | 7 " | 287 " |
| | 28 " | 1,148 " |
| | 42 " | 1,722 " |
| | 56 " | 2,296 " |

| | GENERATING PLANT RUNNING HOURS | AUTOMOBILE RUNNING MILES |
|---|---|---|
| MONTHLY AVERAGE | 30 Hrs. | 1,230 Miles |
| | 120 " | 4,920 " |
| | 180 " | 7,380 " |
| | 240 " | 9,840 " |
| YEARLY AVERAGE | 365 " | 14,965 " |
| | 1,460 " | 59,860 " |
| | 2,190 " | 89,790 " |
| | 2,920 " | 119,720 " |

NOTE: Electric generating plants do not operate economically when used to power electric refrigerators and will add from 4 to 8 operating hours per day in addition to the regular lighting load.

D

The 1500 watt a-c and the 2000 watt d-c electric generating plants described in this manual are powered by a two-cylinder opposed, air-cooled, gasoline driven engine. Each plant is carefully inspected and given a thorough test run before shipment to assure that each plant will produce its rated output and that all parts are in good condition.

Basically the engine is the same for all models with the exception of accessories required for the different types of starting. Differences are in the generator and controls. The type of current, the method of connecting the load, controls for manual start or remote start plants are a few of the main differences. The TABLE OF RATINGS list the various plants covered in this manual. There are three distinct types - portable, remote control and battery charging. The portable units may be either alternating current or direct current plants. The remote control plants produce alternating current as well as direct current for battery charging purposes. The battery charging plants produce direct current only. Where differences in installing, servicing, connecting, operating, adjusting and repairing occur, each will be treated separately. Unless otherwise noted all information given applies to all plants in the table.

## TABLE OF RATINGS

| TYPE PLANT | PLANT WATTAGE | PLANT VOLTAGE | FREQUENCY | CURRENT |
|---|---|---|---|---|
| PORTABLE<br>" | 1500<br>" | 115<br>" | 60 CYCLE<br>50 CYCLE | AC |
| PORTABLE<br>" | 1500<br>" | 230<br>" | 60 CYCLE<br>50 CYCLE | AC |
| REMOTE<br>" | 1500<br>" | 115<br>" | 60 CYCLE<br>50 CYCLE | AC |
| REMOTE<br>" | 1500<br>" | 230<br>" | 60 CYCLE<br>50 CYCLE | AC |
| PORTABLE | 2000 | 115 | | DC |
| PORTABLE | 2000 | 230 | | DC |
| BATTERY CHARGER | 2000 | 32-40 | | DC |

## ENGINE

The engine is a horizontally opposed, two cylinder, L-head, 4 cycle, air-cooled, internal combustion type. The cylinder bore is 2-1/2"; the stroke, 2-1/4"; piston displacement, 22.1 cubic inches; compression ratio, 6.1 to 1. Basic engine constructed of aluminum. Cylinders and crankcase cast as one piece with cast in liners in cylinders. Connecting rods and pistons, aluminum alloy. Three ring pistons with full floating pins. Counterbalanced crankshaft. Extra large aluminum alloy sleeve type main bearings, flanged to take crankshaft endplay. Steel backed babbitt lined sleeve type camshaft bearings. Full pressure lubrication to main and connecting rod bearings provided by gear type oil pump. Other internal working parts are spray lubricated. Valves are of special alloy steel with replaceable insert seats. Efficient cooling is assured by a

large blower wheel, cooling air being forced at high speed over and around the cooling fins of the cylinders and heads. Ignition current is generated by a low-tension flywheel type magneto and two 6-volt coils.

## GENERATOR

GENERAL.- All generators are of the four pole, self-excited type. The pole shoes and field coils mount in a machined steel ring which serves as the frame. The armature is directly connected to the engine crankshaft and turns at engine speed. A ball bearing serves as a turning center for the outboard end of the armature shaft.

PORTABLE A.C. PLANTS.- Field windings - shunt wound, saturated field. The armature contains both a-c and d-c windings. The d-c output is used for excitation and the windings connect to the commutator. The a-c windings connect to the collector rings and supply the main current.

REMOTE CONTROL PLANTS.- Field windings-shunt wound, saturated field with a series field in addition for cranking and battery charging purposes. The armature contains both a-c and d-c windings. The d-c output is used for cranking power, excitation and battery charging purposes, the windings connect to the commutator. The a-c windings connect to the collector rings and supply the main current.

PORTABLE D.C. PLANTS.- Field windings - compound wound with two interpoles for sparkless commutation. Armature contains d-c windings only, the windings connecting to the commutator.

BATTERY CHARGING PLANTS.- Field windings - shunt wound with a series field in addition for cranking purposes. Armature contains d-c windings only, the windings connecting to the commutator.

## CONTROLS

PORTABLE A.C. - D.C.-

Starting is by manual cranking with pull rope. Manual choke provided for starting purposes. Stop button grounds out the ignition system to stop the plant. Receptacles provided for plug-in of electrical load.

REMOTE CONTROL PLANTS.- Starting and stopping is by push button at the plant or by remote control switches connected in parallel with the starting and stopping circuits of the plant. Carburetor choking is automatic. The control box contains a charge rate ammeter, start solenoid, reverse current relay, charge rate voltage regulator, start and stop buttons, battery and load terminals.

BATTERY CHARGING PLANTS.- Starting and stopping is by push button at the plant or at remote control stations connected in parallel with the starting and stopping circuits of the plant. Carburetor choking is automatic. The control box contains a charge rate ammeter, start solenoid, reverse current relay, start-stop buttons and battery terminals.

IMPORTANCE OF PROPER INSTALLATION.- It is important that your plant be properly installed to give good service. Poor ventilation, vibration, dust, dirt, grit, rain and snow are some of the main points contributing to unsatisfactory operation.

The instructions given in the following paragraphs are necessarily of a general nature due to the various locations and conditions under which these plants may be installed and operated. Where the instructions cannot be followed as given, use them as a guide and make the best installation that circumstances permit.

PORTABLE INSTALLATION

Portable plants have a carrying frame that provides for "easy portability" of the plant. Electricity is thus made available at many remote points that could not otherwise be serviced without running power lines which in most cases is not practicable.

Even though your plant is not equipped with a carrying frame it can be used as a portable unit. All of these plants have magneto ignition and can be started manually. Battery charging plants are not recommended for portable service as the batteries must always be connected when operating the plant.

Portable plants may be operated out of doors without an exhaust extension. Exhaust gases must always be piped out of doors when operating the unit inside an enclosure. Exhaust gases are poisonous and excessive inhalation will cause severe sickness if not death. Install a short length of flexible exhaust tubing between the exhaust outlet on the plant and any rigid exhaust pipe to absorb vibration.

When any unit is used in portable service always be sure that the unit sets about level when running. The unit should be securely fastened when moved from place to place in mobile equipment. Articles within such equipment that might fall on the unit and cause damage should also be secured or removed.

STATIONARY INSTALLATION.-

LOCATION.- Select a site for the plant which will be clean, dry, well ventilated and with provisions for heating in very cold weather. The location should also be as near to the center of the electrical load as possible. A damp or dusty location requires more frequent servicing. An unheated location may result in damage to the plant when starting during extremely cold weather as the oil may be too congealed to circulate properly. A poorly ventilated location may cause overheating.

When several buildings are to be serviced with electricity it is much better and costs less to run lines from a central point to each building than to run lines from one building to another. Not only will the voltage drop from plant to load be less but smaller wire can be used to carry the same current without much voltage loss between the plant and the point of service.

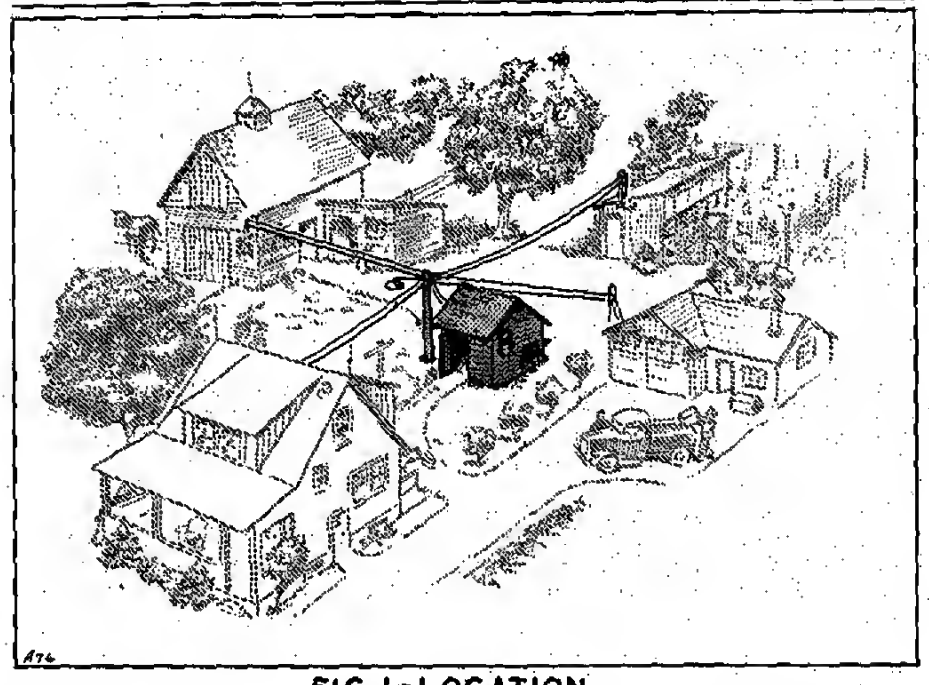


FIG. 1 - LOCATION

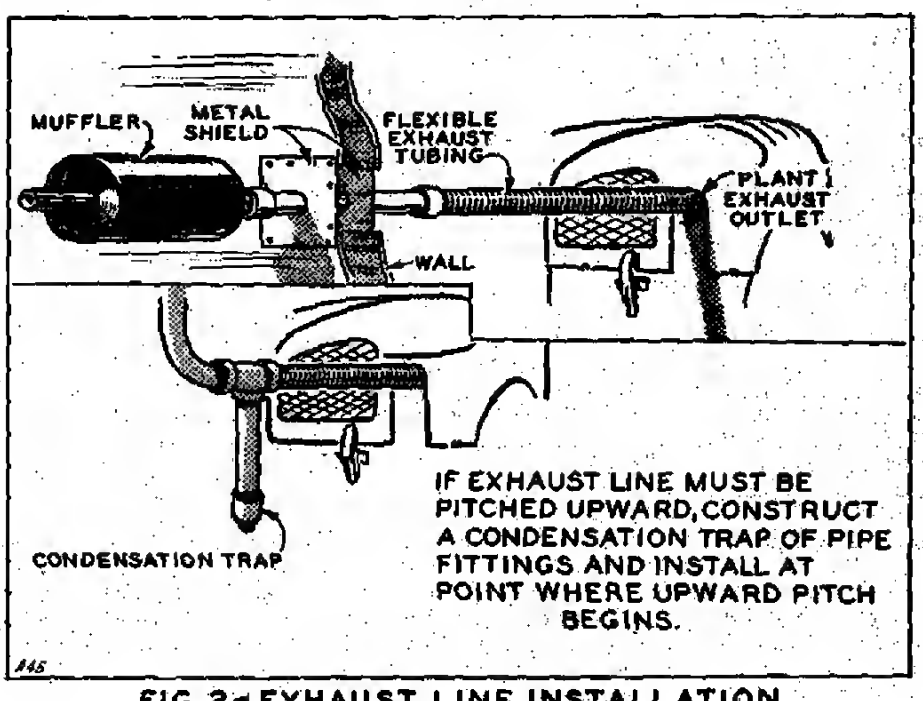



FIG. 2 - EXHAUST LINE INSTALLATION

VENTILATION.- An air cooled engine is cooled entirely by air and requires a large volume of cool air to provide adequate ventilation. Usually normal air circulation is not enough. Additional openings should be provided for incoming cool air and outgoing heated air. These openings should be at least 18" x 18" and should be adjustable to control the volume of cool air for cold weather operation. Openings should be located in such a manner that recirculation of heated air within the enclosure is prevented. Installation of air outlets near the ceiling or in the roof are also helpful in preventing recirculation of heated air.

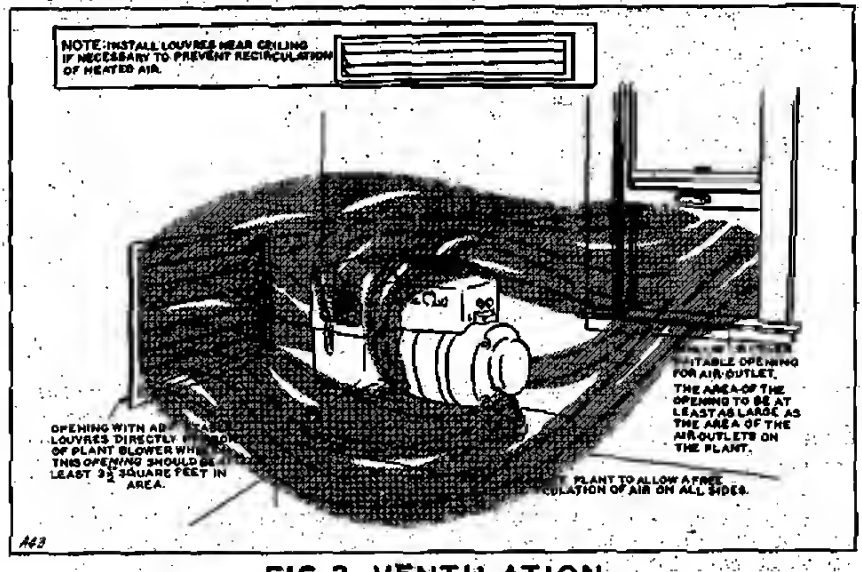



FIG.3-VENTILATION

MOUNTING BASE.- A mounting base of the approximate dimensions shown in Fig. 4 will provide a good substantial foundation for your plant. This base may be either timber or concrete. Locate the mounting base within the enclosure to allow ample space for servicing and reasonably close to the opening provided for incoming cool air.

The base should be a minimum of 12" high x 26" long x 21" wide. Bolts for mounting the plant should be imbedded in a concrete base. Lag screws may be used with a timber base. Mounting hole centers in the oil base are shown in Fig. 4. .

If a concrete base is to be used, a mixture of one part cement, 2 parts sand and 4 parts gravel or crushed stone will make a good base. Suspend three 3/8" x 8" bolts from cross cleats nailed to a concrete form before pouring the concrete. Place a large washer under the head of each bolt and adjust each bolt on the cleat so that it will extend 4" above the concrete and the spacing between bolts conforms to Fig. 4 . Fill the form with concrete and tap down. Do not move the bolts. Be sure the top of the foundation is level and smooth to prevent plant base breakage. Allow the cement to harden for 3 days.

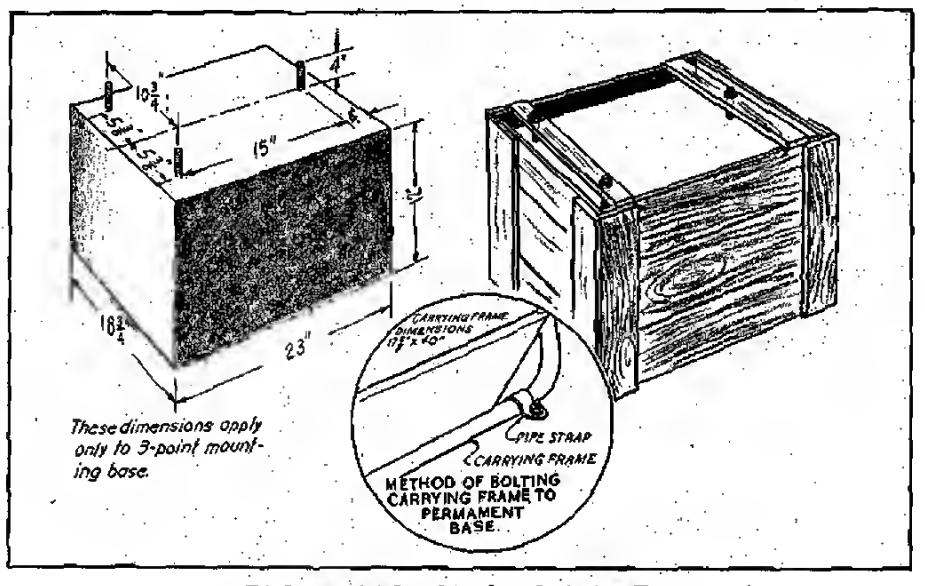



FIG.4-MOUNTING BASE

MOUNTING THE PLANT ON THE BASE.- Use pipe clamps to secure a portable plant to a permanent base and secure as shown in Fig. 5 . Check the mounting cushions for correct assembly as shown in Fig. 5 .

When installing a remote control or battery charging plant on a permanent base, be sure the three lower shock mounting cushions are in place in the plant base before setting the plant on the studs. Assemble the upper mounting cushions and secure as shown in Fig. 5 .

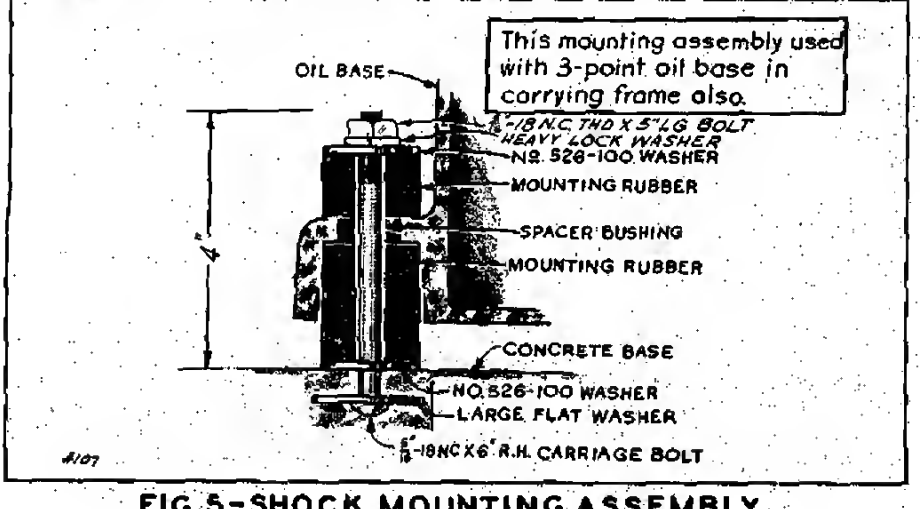



FIG.5-SHOCK MOUNTING ASSEMBLY

MUFFLER INSTALLATION FOR OUTDOOR OPERATION

PORTABLE PLANTS.- The muffler is mounted directly on the engine and an exhaust extension is not required.

OTHER PLANTS.- Attach a length of flexible tubing to the exhaust outlet on the plant and attach the muffler to the tubing. Support the muffler in some manner so that it does not make contact with inflammable material.

MUFFLER INSTALLATION FOR INDOOR OPERATION

All exhaust gases must be piped out of doors. Use 1 inch pipe from the exhaust outlet on the plant for the first 10 feet. Increase the pipe size one size for each additional 10 feet needed. Install a length of flexible exhaust tubing between the plant and any solid exhaust line or connection. Keep the exhaust pipe several inches away from inflammable material. Provide shields for the exhaust line whenever it passes through a wall or partition, the opening for the shields being at least 4" larger on all sides than the exhaust line. Follow suggestions given in Fig. 2 .

The muffler of the portable plant is mounted directly on the plant. The muffler shown in Fig. 2 , is not required in addition for these plants.

CONDENSATION TRAP.- If the exhaust line must be pitched upward at any point, construct a condensation trap of suitable pipe fittings and install at the point where the upward pitch begins. The trap must be drained from time to time to serve its intended purpose. See Fig. 2 .

UNDERGROUND EXHAUST MUFFLER.- An underground exhaust muffler may be installed with a permanent installation. However, if there is danger of the muffler filling with water at any time it cannot be used. A 15 gallon drum with the bottom removed is suitable for the muffler. Do not use a drum that formerly contained gasoline, turpentine or other inflammable liquids. See Figs. 5A and 5B for typical installations.

BATTERY CONNECTIONS.-

When starting batteries are supplied with a plant they are shipped ready for use in the United States, Canada and Mexico. These batteries are in a well charged condition when shipped from the factory. However, if they are not placed in service within 30 to 40 days, they may have become partly discharged. If such is the case, the batteries should be given a freshening charge before being placed in service. Batteries supplied for use in other countries must be prepared for use according to the instructions given on the tag attached to the batteries.

Batteries should always be set on a wooden or metal rack to afford a free circulation of air around the battery.

Cables for making connections between the plant and the battery are supplied with all remote control plants even though the starting batteries are not. Neither batteries nor cables are supplied with battery charging plants.

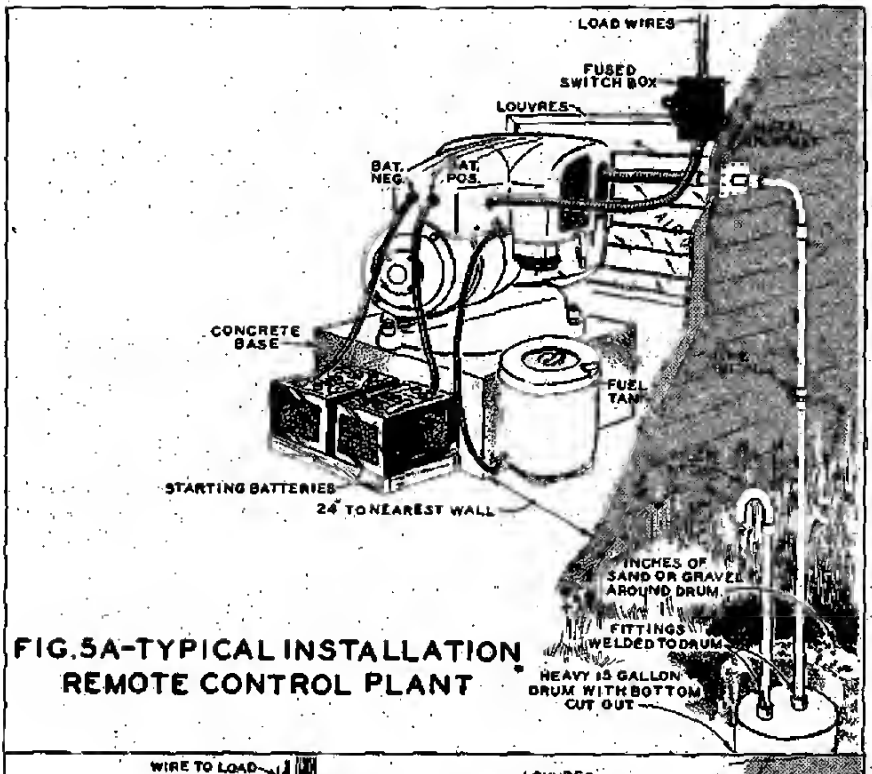



FIG. 5A–TYPICAL INSTALLATION REMOTE CONTROL PLANT

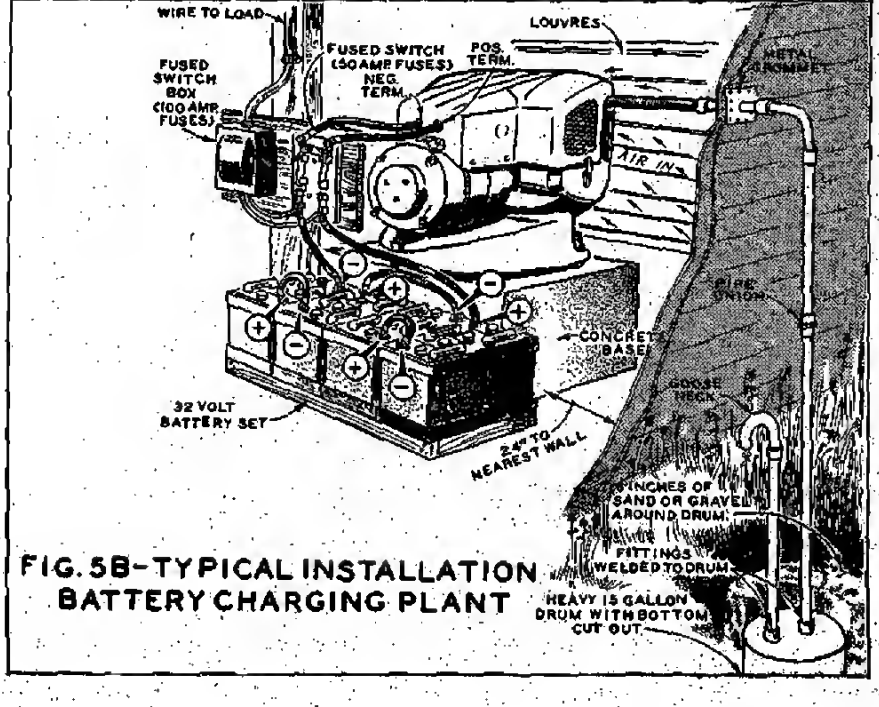



FIG. 5B–TYPICAL INSTALLATION BATTERY CHARGING PLANT

When making cable connections at the battery it may be necessary to spread the cable lug open slightly before it will fit properly over the terminal post. Don't use a hammer to drive cable lugs onto battery terminal posts, the battery may be damaged. Cable lugs should have full contact on battery terminal posts to present loss of current at this point. Be sure contact surfaces of lug and terminal post are clean before making connections. Coat lugs and terminal posts with vaseline to help prevent corrosion.

REMOTE CONTROL PLANTS.- Connect the short jumper cable from the negative (-) post of one battery to the positive (+) post of the second battery. Connect one of the long cables from the remaining positive (+) post of the battery to the POSITIVE terminal in the plant control box. Connect the other long cable from the remaining negative (-) post on the battery to the NEGATIVE terminal in the plant control box. Be sure connections are tight at all points.

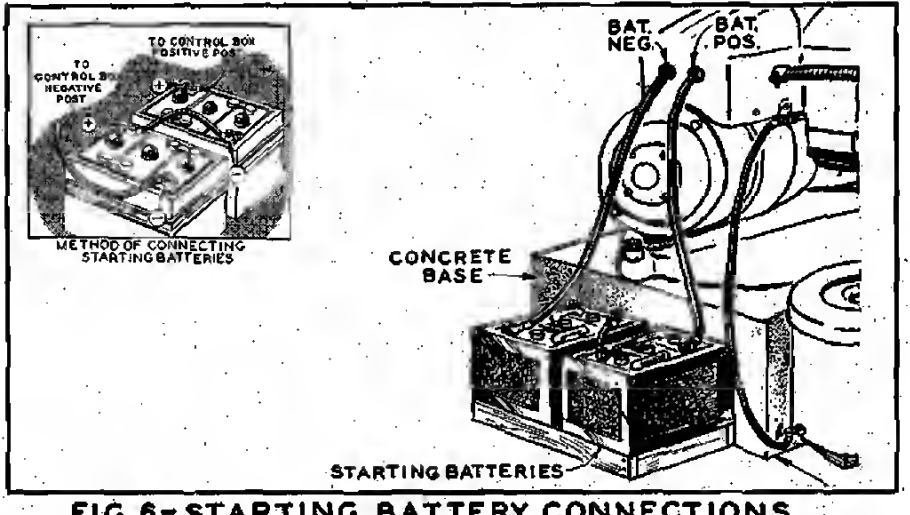



FIG.6-STARTING BATTERY CONNECTIONS

BATTERY CHARGING PLANTS.- Batteries for these plants should be prepared for use according to the instructions supplied by the battery manufacturer. Several makes of automotive or glass jar type are available on the market. Your dealer can recommend the type best suited for your installation.

Battery cables are not supplied for these plants. Your dealer should be able to supply you with correct size and length of cable needed for your installation. Cables should be of the same size and length and the length should be held to a minimum.

A single throw, double pole, fused switch should be installed in the cable line between the plant and the battery. See Fig. 7 . The switch must have 100 ampere capacity. Be sure 100 ampere fuses are used in the switch. See your dealer. If he cannot supply you with a proper switch, they are available at most electrical supply houses.

Connect a short length of cable from the battery positive (+) post to the hot side of the fused switch. Connect a second length of cable from the hot side of the switch to the POSITIVE terminal in the plant control box. See Fig. 7 .

Connect a short length of cable from the battery negative (-) post to the ground side of the fused switch. Connect a second length of cable from the ground side of the switch to the NEGATIVE terminal in the plant control box. See Fig. 7 .

Keep the switch closed at all times unless making connections or working on the plant.

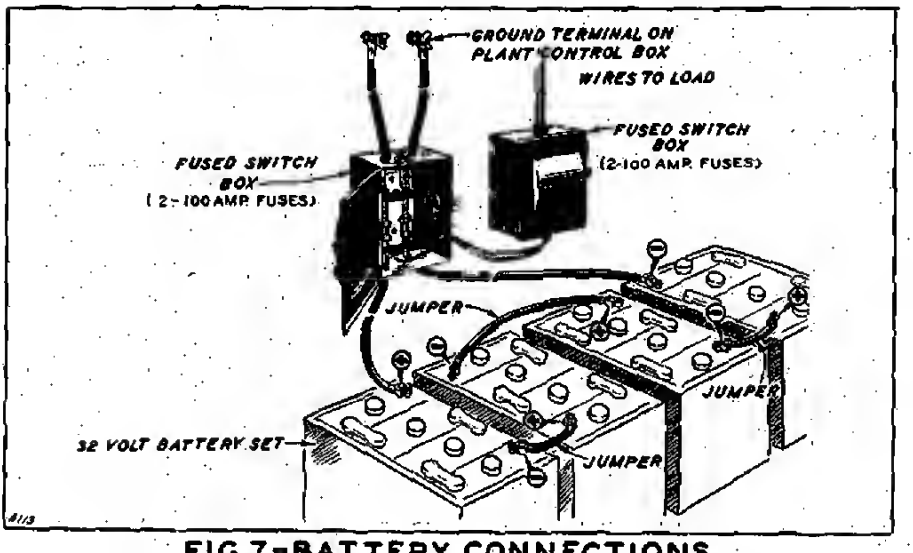



FIG. 7-BATTERY CONNECTIONS -BATTERY CHARGING PLANT

REMOTE CONTROL CONNECTIONS

BATTERY CHARGING AND REMOTE CONTROL PLANTS.- Remote start-stop stations may be installed at various points within 1000 feet of the plant. These stations permit starting and stopping the plant from various locations saving many steps when current is required from other buildings. Use No. 18 wire up to 250 feet, No. 16 wire up to 500 feet and No. 14 wire up to 1000 feet.

Refer to Fig. 8 . Note that the remote control terminal block is marked "REMOTE CONTROL" B , 1, 2 and 3. Terminal No. 1 is a common ground. Terminal No. 2 is in the stopping circuit. Terminal No. 3 is in the starting circuit. Terminal marked B+ is used only with automatic control equipment.

Examine the remote control switch supplied with your plant. Note that the switch also has terminals marked 1, 2 and 3. Make connections between the plant and the switch as shown in Fig. 8 , using one lead wire between each numbered terminal (a lead from 1 to 1, 2 to 2 and 3 to 3) Additional switches may be connected either directly at the remote control panel or in parallel with other remote start-stop switches.

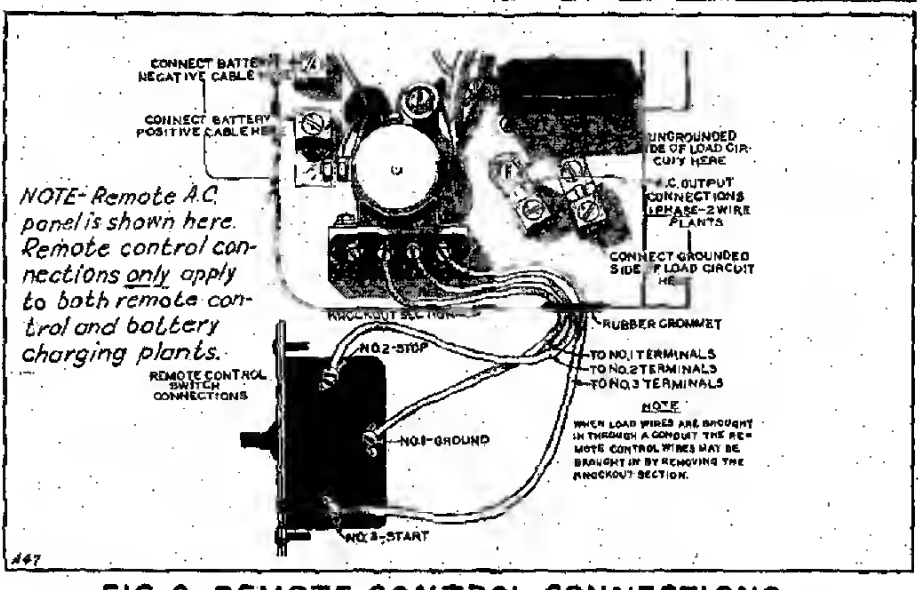



FIG. 8-REMOTE CONTROL CONNECTIONS

GROUNDING THE PLANT.- If grounding is called for in local codes or radio interference can be reduced by grounding, drive a 1/2 inch pipe into the *ground* as close to the plant as you can. This pipe must penetrate moist earth. Then connect a suitable ground clamp to this pipe and run a No. 10 or No. 12 wire to either the NEGATIVE battery terminal or to the grounded main line wire at the plant. Never connect this wire to a water pipe or to a ground used by a radio system.

WIRING.- Use insulated wire of the correct size to connect the load to the plant. The wire size will depend largely on the distance and permissible voltage drop between the plant and the load and the amount and kind of load. Consult your dealer for advice. If necessary see a competent electrician. Check national and local codes before installing. Install a fused switch or circuit breaker in the line between the load and the plant at a point near the plant.

Leads that must be joined together should be connected with solderless connectors and thoroughly taped with two layers of half-lapped electricians' tape and two layers of half-lapped friction tape, extending both well beyond the ends of the connection. Leads that connect directly to terminals do not require taping.

Protect each branch circuit of the system with a fuse of the proper amperage according to the carrying capacity of the wire regardless of the total load that may be connected to the branch circuit. Such fuses are in addition to the main fuse that protects the entire system.

## WIRING TABLE

Unity Power Factor. 2% Voltage Drop 115 V. A.C. - D.C.

| WIRE SIZE NO. | | 14 | 12 | 10 | 8 | 6 | 4 | 2 |
|---|---|---|---|---|---|---|---|---|
| Watts | Amps. | * Distances expressed in feet per wire size. | | | | | | |
| 100 | .87 | 510 | 810 | 1280 | 2040 | 3250 | 5300 | 8200 |
| 200 | 1.74 | 255 | 405 | 640 | 1020 | 1625 | 2650 | 4100 |
| 300 | 2.61 | 170 | 270 | 430 | 680 | 1080 | 1770 | 2730 |
| 400 | 3.48 | 125 | 200 | 320 | 510 | 810 | 1325 | 2050 |
| 500 | 4.35 | 100 | 160 | 255 | 410 | 650 | 1060 | 1640 |
| 750 | 6.52 | 65 | 100 | 170 | 275 | 430 | 710 | 1090 |
| 1000 | 8.69 | 50 | 80 | 125 | 205 | 325 | 530 | 820 |
| 1500 | 13.04 | 35 | 55 | 85 | 140 | 215 | 350 | 550 |

* Above figures represent a point to point distance for a 2 wire run. If a 4% voltage drop is permissible, double the distance listed. If only 1% voltage drop is allowable, divide the distances listed by 2.

Single Phase 115 Volt A.C. or 115V. D.C. - Use 115 Volt table.

Single Phase 115-230 Volt A.C. 3 Wire - Use 115 Volt table for each 115 Volt Circuit.

Single Phase 230 Volt A.C. or 230 V. D.C. - Double the distances in the 115 Volt table. Use Amps. Column.

Three Phase 230 Volt circuit. - Multiply the distances in the 115 V. table by 2-1/4 for the same load. Use the Amps column.

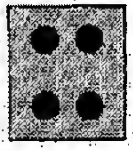
Table of Wire Sizes for 32 Volt - 2% (.64) Voltage Drop

| WIRE SIZE NO. | | 12 | 10 | 8 | 6 | 4 | 2 | 0 |
|---|---|---|---|---|---|---|---|---|
| Watts | Amps. | * Distances expressed in feet per wire size. | | | | | | |
| 50 | 1.56 | 120 | 200 | 320 | 490 | 800 | 1200 | — |
| 100 | 3.13 | 60 | 100 | 160 | 245 | 400 | 600 | — |
| 150 | 4.69 | 40 | 70 | 110 | 165 | 260 | 400 | — |
| 200 | 6.25 | 30 | 50 | 80 | 125 | 200 | 300 | — |
| 250 | 7.81 | 25 | 40 | 65 | 100 | 160 | 240 | — |
| 300 | 9.38 | 20 | 35 | 55 | 80 | 130 | 200 | — |
| 400 | 12.50 | 15 | 25 | 40 | 60 | 100 | 150 | — |
| 500 | 15.63 | 12 | 20 | 30 | 50 | 80 | 120 | — |
| 600 | 18.75 | 10 | 15 | 25 | 40 | 65 | 100 | — |
| 800 | 25.00 | — | 12 | 20 | 30 | 50 | 75 | — |
| 1000 | 31.25 | — | 10 | 15 | 25 | 40 | 60 | — |
| 1200 | 37.50 | — | — | 12 | 20 | 30 | 50 | — |
| 1400 | 43.85 | — | — | 10 | 15 | 25 | 45 | — |
| 1500 | 46.88 | — | — | — | 10 | 20 | 40 | — |
| 2000 | 62.50 | — | — | — | — | — | 10 | 15 |

* Above figures represent a point to point distance for a 2 wire run.
If 4% voltage drop is permissible, double the distances listed.
If only 1% voltage drop is allowable, divide the distances listed by 2.

CONNECTING THE LOAD

PORTABLE A-C PLANTS.- These plants are equipped with an outlet box which has several receptacles in it. The load connects directly at these receptacles. Install a suitable plug on the load wires or appliance and plug into a receptacle on the plant. All receptacles may be used at the same time but the amperage output from these receptacles must not exceed the rated output of the generator whether one or all receptacles are used at the same time. Amperage output is as follows.



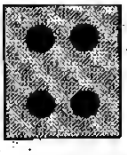
ON A 115 VOLT PLANT, 115 VOLT SINGLE PHASE CURRENT MAY BE OBTAINED FROM ANY RECEPTACLE.
ON A 230 VOLT PLANT, 230 VOLT SINGLE PHASE CURRENT MAY BE OBTAINED FROM ANY RECEPTACLE.

FIG.9-LOAD CONNECTIONS -PORTABLE A.C. PLANTS

1500 Watts at 115 Volts = About 13 Amperes.
1500 Watts at 230 Volts = About 6-1/2 Amperes.

CAUTION.- All electrical equipment operated from your plant must carry the same current voltage, phase and frequency rating as the plant. Universal equipment as a rule will operate from either a-c or d-c if the voltage is the same.

PORTABLE D-C PLANTS.- These plants are equipped with an outlet box which has several receptacles in it. The load connects directly at these receptacles. Install a suitable plug on the load wires or appliance and plug into a receptacle on the plant. All receptacles may be used at the same time but the amperage output from any one receptacle must not exceed 15 amperes and the total demand in watts must not exceed the rated output of the generator whether one or all receptacles are used at the same time. Amperage output is as follows:



ON A 115 VOLT PLANT, 115 VOLT CURRENT MAY BE OBTAINED FROM ANY RECEPTACLE.
ON A 230 VOLT PLANT 230 VOLT CURRENT MAY BE OBTAINED FROM ANY RECEPTACLE.

FIG.10-LOAD CONNECTIONS -PORTABLE D.C. PLANTS

2000 Watts at 115 Volts = About 17 Amperes.
2000 Watts at 230 Volts = About 9 Amperes.

CAUTION.- All electrical equipment operated from your plant must carry the same current and voltage rating as the plant. Universal equipment as a rule will operate from either a-c or d-c if the voltage is the same.

REMOTE CONTROL PLANTS.- Load connections are made within the control box on the plant. The load terminals are located just in front of the grommet towards the rear of the control box. Solderless terminals are provided for this purpose. The terminal nearest the start solenoid is the hot terminal, the other terminal is grounded. Connections described are for single phase, two wire plants only.

Thoroughly strip 3/8" of insulation from the end of each main line wire. Insert the black main line wire from the switch or circuit breaker into the hot terminal and tighten the terminal screw securely. Insert the white wire into the grounded terminal and tighten the terminal screw securely. See Fig. 11.

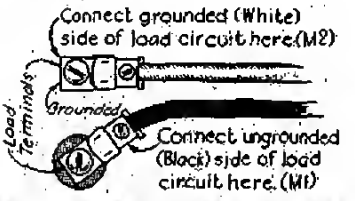



FIG. 11—SINGLE PHASE, 2 WIRE CONNECTIONS

BATTERY CHARGING PLANTS.- The 32-volt load may be connected directly to the battery switch terminals as shown in Fig. 7 . The load should never be connected to the battery terminals in the plant control box. Install a fused main switch between the battery switch and the 32 volt load, the switch to have 100 ampere fuses. Make sure the wire from the battery switch to the load switch is large enough to carry the entire output of the battery plus the output of the generator. Smaller wire may be used for branch circuits from the load switch, the size depending on the amount and kind of load. Make sure all appliances, motors, lights, etc. that may be operated from this plant are for operation on 32 volts. Clean all terminals and connectors before making the installation. Then proceed as follows.

Connect the hot side of the d-c circuit to the hot side of the battery switch as shown in Fig. 7 . Connect the grounded side of the circuit to the grounded battery switch terminal. Observe the same polarity for branch circuits at the load switch.

OIL DRAIN EXTENSION (Remote Control Plants).-

Remove the oil drain plug from the oil base and install the pipe nipple and coupling supplied with the plant. Then install the drain plug in the coupling.

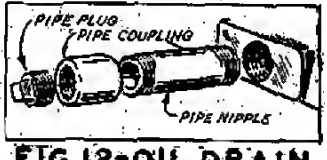



FIG. 12—OIL DRAIN EXTENSION

FUEL TANK AND FUEL LINE INSTALLATION.- Install the fuel tank and fuel lines as shown in Fig. 13. Be sure the top of tank is not less than 6" below the fuel pump inlet and the bottom of the tank not more than 6' below the fuel pump inlet. Portable plants have the fuel tank mounted in the carrying frame. Re-

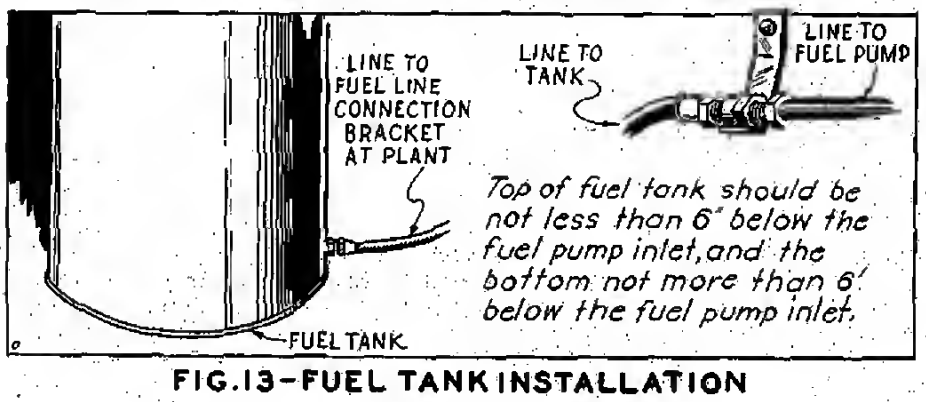



FIG. 13—FUEL TANK INSTALLATION

mote control plants have a separate 5 gallon tank. Install the shut-off velve assembly at the bottom opening in the tank. Connect the non-swivel end of the flexible line at the plant fuel connection (See Fig. 13.) and the swivel end at the tank shut-off valve.

GASEOUS FUEL CONNECTIONS.- If your plant ie equipped to use gaseous fuel (Propane, Butane or Natural Gas) a pressure regulator and flexible hose are supplied. The regulator inlet is threaded for 3/4" iron pipe. The gas line pressure entering the secondary regulator supplied with the plant must not exceed 6 ounces. If it exceeds this value a primary regulator muet be installed to reduce the line pressure to 6 ouncee or leee. Consult your fuel dealer if the line pressure is not known. Be sure the installation conforms to gae code specifications.

Connect the secondary regulator in an upright position ae shown in Fig. 14. Connect the flexible hose to the regulator outlet and then to the fuel inlet pipe on the carburetor. Tighten the clamp at the carburetor end of the hose securely. The small idle adjueting screw on the regulator is inoperative but should not be removed.

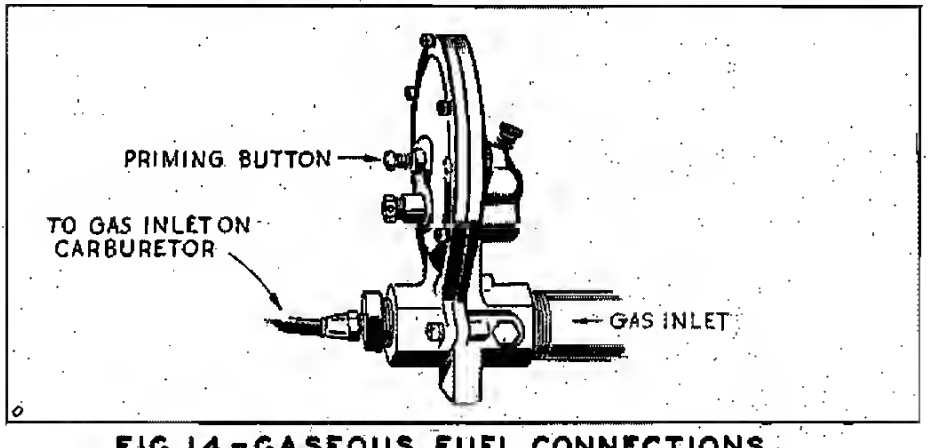



FIG. 14 - GASEOUS FUEL CONNECTIONS

DO NOT OPERATE YOUR PLANT UNTIL IT HAS BEEN PROPERLY SERVICED WITH FUEL AND OIL AS RECOMMENDED IN THE FOLLOWING PARAGRAPHS.

LUBRICATION.- The use of a good heavy duty detergent type oil in the engine crankcase greatly increases the life of pistons and piston rings. Its use is strongly recommended.

CAUTION.- If a change is made to a detergent type oil after using a non-detergent type, allow only 1/3 the normal operating hours before changing oil for each of the next two change periods. Change oil at regular intervals thereafter.

Crankcase oil capacity is 2 quarts (U.S. Measure). Fill with the correct SAE number oil according to the lowest temperature to which the plant will be exposed. See the table. Do not overfill. The connecting rods may strike the oil, causing it to foam, interfering with proper lubrication. The oil level indicator is mounted on the oil filler cap. The upper mark on the gauge indicates a safe high oil level. The lower mark on the gauge indicates that the oil level is at the danger mark and oil must be added or the oil changed.

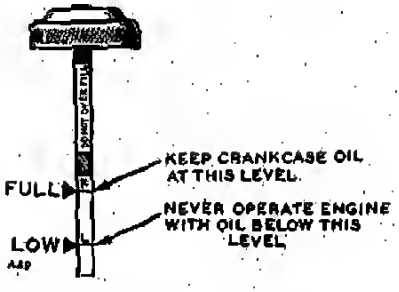



FIG.15-OIL LEVEL INDICATOR

| LOWEST TEMPERATURE AT THE PLANT | SAE NUMBER OIL |
|---|---|
| Above 90° F. (32° C.) For Heavy Duty Operation | No. 50 |
| Between 30° F. (32° C.) (-1° C. and 32° C.) | No. 30 |
| Between 0° F. and 30° F. (-18° C. and -1° C.) | No. 10 |
| Below 0° F. (-18° C.) | No. 5 |

CAUTION.- A partial vacuum is created in the crankcase when the plant is in operation. Should an air leak occur at the oil filler opening or should the check valve assembly in the breather tube fail to operate properly, oil leakage at the oil seals ie likely to result as the partial vacuum would be destroyed.

Fill the air cleaner cup to the level marked inside the cup with the same grade of oil used in the engine crankcase, except as noted for cold weather operation.


FIG.16-AIR CLEANER OIL LEVEL

Place a drop of oil on each joint of the throttle control linkage.

FUEL (Gasoline).- Fill the fuel tank nearly full with clean, fresh regular gasoline of 68 to 74 octane. Do not use premium grade gasoline. Engine life will be greatest when fuel containing the smallest amount of lead is used. NEVER FILL THE FUEL TANK WITH THE ENGINE RUNNING AND DON'T FILL THE TANK ENTIRELY FULL. The gasoline may expand and overflow, causing a fire hazard.

GASEOUS FUEL.- Follow national and local codes when installing fuel pipes and fuel containers according to the type of fuel being used. A secondary regulator is supplied with each plant ordered for gaseous fuel operation, also with the conversion kit. If the line pressure exceeds 4 to 6 ounces per square inch a primary regulator is required to reduce the pressure before it enters the secondary regulator.

PRELIMINARY.- Before starting your plant make a final check to see that the plant has been installed as recommended and that it has been serviced properly with fuel and oil. If your plant has been prepared for cold weather operation, refer to the section on ABNORMAL OPERATION CONDITIONS to see that all necessary precautions have been taken.

STARTING REMOTE CONTROL AND BATTERY CHARGING PLANTS

Before starting a new plant or a plant that has run out of fuel, quite a few revolutions of the crankshaft will be necessary to fill the carburetor with gasoline. Open the fuel line shut-off valve at the fuel tank until it backseats. Then press the START button in firmly. Hold the start button in for about five seconds, then release it if the engine hasn't started. Wait about five seconds and repeat if necessary. Choking is automatic and the engine should start as soon as gasoline reaches the cylinders. If the plant does not start after a few attempts, check the fuel and ignition systems and repeat the starting procedure after correcting any trouble found. After the initial start the engine should start at the first attempt.

If the charged condition of the starting batteries is so low that they do not have power enough to crank the plant, start it manually as follows:

Wind the starting rope in a clockwise direction around the rope sheave and give a strong steady pull the full length of the rope. Choking is automatic and the plant should start at the first attempt. Repeat if necessary. If the plant does not start readily, check the fuel and ignition systems and repeat the cranking after correcting any trouble found.

NOTICE - ALL PLANTS

Oil was placed in the cylinders before the plant was shipped and it may be necessary to remove the spark plugs and clean them in gasoline before the plant will start the first time.

STARTING PORTABLE PLANTS

Before starting a new plant or a plant that has run out of fuel, quite a few revolutions of the crankshaft will be necessary to fill the fuel system with gasoline. Open the fuel line shut off valve at the tank. Then pull the choke control knob out 3/4 of the way. Wind the starting rope in a clockwise direction around the rope sheave. Then give a strong steady pull the full length of the rope. Repeat until the engine starts. As the engine begins to warm up, slowly push the choke control knob in until it is all the way in with the engine running smoothly. After the initial starting of the engine it will usually start at the first attempt. If it does not, push the choke control knob part way in before cranking the engine again. If the engine does not start readily after the initial start, check the fuel and ignition systems and correct any trouble found.

WHEN TO OPERATE THE PLANT

BATTERY CHARGING PLANTS.- The plant must be operated whenever it becomes necessary to recharge the batteries. Electricity may be used while the plant is running, or as limited by the capacity and charge of the battery, while the plant is not running. The total electrical load may be double the plant capacity, or even more, for the period of time that the battery remains in a well charged condition. To avoid possible damage to the genarator, NEVER OPERATE THE PLANT WITHOUT HAVING THE BATTERY CONNECTED TO THE PLANT.

OTHER TYPE PLANTS.- All plants other than the battery charging type deliver current directly to the load and must be operated whenever electricity is required. The plant may be operated at no load if electrical load demand is intermittent.

CAUTION.- Continuous overloading of any generator will cause the generator temperature to rise to a dangerous point and may result in serious damage to the windings. The generetor will safely handle an overload temporarily but for continuous operation keep the load within the rating given on the plant nameplate.

BATTERY CHARGING RATE

BATTERY CHARGING PLANTS.- Best results will be obtained if the charging rate is held to a minimum until the plant has thoroughly warmed up. The battery charge rate is in proportion to engine speed and both are regulated by the tension applied to the governor spring. A knurled nut attached to the speed adjusting stud permits a quick adjuetment. See Fig. 24. Turn the nut in to increase engine speed and charge rate. Turn the nut out to decrease engine speed and charge rate. The charge rate is indicated on the ammeter. Follow the recommendations of the battery manufacturer as to the correct rate of charge. Do not overcharge the battery nor charge at an excessive rate.

Most battery manufacturers recommend "cycling" the battery. This means that a fully charged battery should be used until at leest 85% discharged, then recharged fully. Repeat through complete cycles of charge and discharge for maximum battery life. Keeping a battery at a full state of charge without cycling may shorten its life as much as 75%.

REMOTE CONTROL PLANTS.- Battery charge rate is controlled by a two step voltage regulator which automatically controls the charge rate.

## INSTRUCTIONS FOR OPERATING PLANTS EQUIPPED FOR GASEOUS FUEL

CAUTION

The regulator mounted on the plant is designed to operate on a gas line pressure not to exceed 4 to 6 ounces per square inch. If the line pressure exceeds this value it will be necessary to install a primary regulator to reduce the pressure.

STARTING.- Ths carburstor choke must be left in ths wide open position. No choking is necessary when geseous fuel is used. The carburetor on bettery charging and remote control plants is equipped with a locking device to lock the carburetor choke fly in the wide open poeition. Slide the choke lock sleeve from the carburetor as far as possible, turn the choke shaft knob to completely open the carburetor choke, and tighten the locking screw to hold the choke knob in position.

See that no gesoline is in the carburetor. Turn the carburetor float lock screw in to the limit of its travel. See Fig. 22.

The regulator mounted on ths engine is provided with a priming button which may have to be pressed momentarily to start the engine. Do not hold the priming button in, just press for an instant. Avoid overpriming.

For manually starting e plant equipped for gas fuel, the gas should have a BTU rating above 800 BTU per cu. ft. The temperature should be above 30° F. (-1° C) to permit sufficient cranking speed to be developed to create and meintain sufficient intake vacuum for starting. Load should be disconnected.

Unless the ges to be used is of approximetely the same BTU rating as used by the manufacturer, it will be necessary to readjust the carburetor. See Fig. 22. If 1100 BTU gas is to be used, close ths main gas adjustment to epproximately 3-1/2 turns open. If Propane gas is to be used, close the adjustment to approximately 3 turns open. A power loss of 15% to 20% from the ratsd power may be expected when using 800 BTU gas. No power loss may be expsctsd when using e gas of 1100 BTU or higher. Make a final edjustment of the cerburetor after the engine becomes warmed up.

Adjust the carburetor with the full load on the plant. Turn the main gas adjustment screw in until the engine begins to lose speed from lack of fuel. Slowly turn the adjusting screw out until the engine will carry the full load smoothly. Remove all load and adjust the idle adjustment screw in the same manner.

GASOLINE CHANGE-OVER.- The gas equipped plant may be operated on gasoline fuel if it bscomes necessary or desirable. Turn off the ges fuel supply. If ths ges fuel supply line is disconnected, install a pipe plug in the reguletor inlet. If the gas fuel line is disconnected between the reguletor and the carburetor, close both the main and idle gas adjustmsnt screws. Failure to do this will result in improper carburetion.

On the battery charging and remote control type plants, release the slectric choke locking device, checking to bs sure thet the choke will operate properly.

Beck out the carburetor float lock screw until it backseats firmly. The screw must backseat properly to prevent leakage of gasoline at this point. Fill the fusl tank, opsn the gesoline shut-off valve and check carefully for leaks.

The plant may then be started and operated es e standard gasoline burning plant, keeping in mind that the carburetor bowl must become filled with gesoline before the plant will start the first time. Make any necessary carburetor adjustments efter the plant warms up.

If returning to gas operation after operating on gasoline fuel, turn off the gasoline supply and permit the plant to run until the gasoline remaining in the carburetor is exhausted.

STOPPING THE PLANT

Disconnect the load from the plant if practicable.

Stop battery charging or remote control plants by firmly pressing the STOP button at the control box or remote stop station until the plant comes to a complete stop.

Stop portable plants by firmly pressing the STOP button on the blower housing until the plant comes to a complete stop.

These plants have magneto ignition systems which fire at very low r.p.m. If the stop button is released too soon, the plant will pick up speed and continue to run.

## LOW TEMPERATURES

LUBRICATION.- When operating your plant at temperatures of 0° F. (-18°C) and below and the crankcase oil has not previously been prepared for operation at these temperatures, proceed as follows:

1. Remove the drain plug from the oil drain fitting and drain the old oil from the crankcase while the engine is warm. Then replace the drain plug.

   CAUTION.- Starting your engine at low temperatures with heavy oil in the crankcase may cause serious damage through lack lubrication. If the oil in the crankcase is heavier than SAE No. 10 and the plant has been standing idle in an unheated location, place the plant in a heated room or heat the space in which the plant is located. Allow the engine to warm up until the oil will flow freely from the oil drain before attempting to start the plant. Then start the plant and run it for several minutes to warm it up before draining the oil. NEVER ADD KEROSENE ALONE TO THE CRANKCASE TO DILUTE THE OIL.

2. Refill the crankcase to the high mark on the oil level indicator with SAE No. 5 oil. Then start the plant immediately and run for at least 10 minutes to thoroughly circulate the oil.

When using No. 5 oil, change oil every 100 operating hours and check the crankcase oil level at least once every 8 operating hours.

AIR CLEANER.- If SAE No. 10 or No. 5 oil is being used and it thickens or if frost forms inside the air cleaner and holds back the flow of air, remove the air cleaner and clean it. Reassemble the air cleaner and use it without oil until the weather warms up enough to allow using oil in the air cleaner again.

FUEL.- Give special attention to fuel. Fresh fuel and high test fuel aid starting. Never fill the fuel tank entirely full with gasoline as it may expand and overflow creating a fire hazard. NOTE: A vapor lock may occur when using winter grade fuel if the plant is operated in an enclosed room where the temperature exceeds 70° F. When the plant is running the blower will cool the pump sufficiently. After the engine has been stopped for 10 to 20 minutes the fuel pump reaches its highest temperature and vapor lock is most likely to occur. If vapor lock occurs, the ambient temperature at the plant is too high. Open existing ventilators more or provide additional ventilation.

HEATING.- If the plant is operated under extremely cold operating conditions, it may be necessary to provide some means for heating the space in which the plant is located.

ELECTRIC CHOKE.- It may be necessary to adjust the electric choke for easy starting during cold temperatures. Refer to the Accessory Service section for instructions on adjusting.

BATTERY.- Keep the battery well charged at temperatures below 32° F. (-1° C.) to avoid any possibility of its freezing and to assure ample power for cranking the plant electrically. Cold temperatures lower the capacity of the battery and may, if the battery is in a discharged condition, cause the water in the battery to freeze, damaging the battery. At a specific gravity reading of 1.100, the

electrolyte will freeze at about 19° F. while with e epecific grevity reading of 1.250 it will withstand a temperature of-62° F. The effect of cold temperatures on the battery may be more readily appreciated if it is known that the cranking power of a battery at 0° F. ie reduced to only 2/5 of its normal power and that the cranking load ie increased 2-1/2 times the warm weather load due to stiff oil. If the plant is to remain idle for any length of time during cold weather, it is well to disconnect the battery and store it in a warm piece. If this period extends beyond 30 days, the battery should be given a freshening charge every 30 to 40 days.

## HIGH TEMPERATURES

Under extremely warm operating conditions, provide ample ventilation and keep the oil level at the high mark on the gauge at all timee. Keep all cooling surfaces and air passages clean and free of dust, dirt, and grease. Change oil every 100 operating hours.

## DUST AND DIRT

Keep the plant as clean as you can. Check the operation oftener and service as needed. Clean the air cleaner more often. Clean the generator commutator, collector rings and brushes often and see that the brushes ride freely in their holders and make good contact. Keep supplies of fuel and oil in air tight containers.

GENERAL.- A set schedule of inspection and service will help you to keep your plant in good running order at all times and cut down on running expenses. Service periods given are for normal operation. For extreme conditions of load, temperature, frequent starts, dust and dirt, service the plant more often.

## DAILY SERVICE

If your plant is to be operated more than 8 hours daily, perform the following services at the end of each 8 hours of operation.

FUEL.- The amount of fuel used will vary between plants. Check the fuel supply often for a few days until you become familiar with the amount of fuel used and how long a tankful will last before it needs refilling. Refill the tank often enough to assure having fuel in the tank at all times. Use clean, fresh, regular gasoline of 68 to 74 octane. Do not use premium grade gasoline. NEVER FILL THE FUEL TANK WITH THE ENGINE RUNNING.

CRANKCASE OIL LEVEL.- Check the crankcase oil level often during the break in period, the rings may not be completely seated and the plant may use some oil until they do become seated. Check the oil at least once each 8 hours of running time afterward. If necessary, add proper oil to bring the oil level to the full mark on the gauge. Do not overfill as the connecting rods may strike the oil, causing it to foam, interfering with proper lubrication. Never allow your plant to run with the oil level below the low mark on the gauge.

NOTE: Always be sure the oil filler cap is replaced tightly on the oil fill opening and that the gasket is in good order. Air leaking into the oil base from this point may cause loss of power or excessive oil consumption. If there is light blue, smoky exhaust coming from the exhaust outlet of the plant, check the oil fill cap for air leaks before making any additional checks.

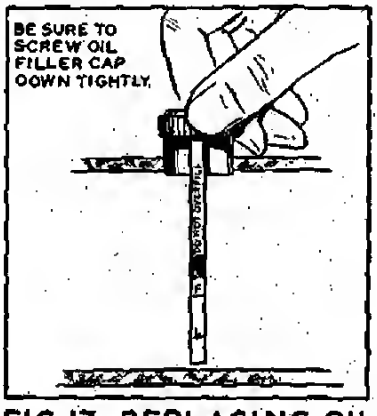



FIG.17-REPLACING OIL FILLER CAP

AIR CLEANER.- Turn the thumb screw, located at the bottom center of the air cleaner cup, out as far as it will go and remove the cup. Check the oil level. If necessary refill the cup to the indicated level with oil of the same SAE number as used in the engine crankcase, except as noted under ABNORMAL OPERATING CONDITIONS.

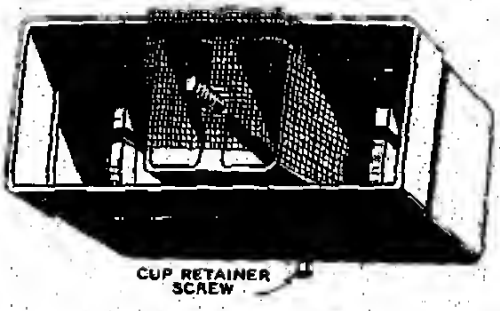



FIG.18-AIR CLEANER CUP AND SCREEN

GENERAL.- Keep your plant as clean as you can by wiping it off with a rag each time you service it. Do not leave oily rags laying around as they are a fire hazard. Keep them in a metal container.

## WEEKLY SERVICE

If your plant is to be operated more than 50 hours weekly, perform the following services at the end of each 50 hours of operation.

LUBRICATION.- The oil should be changed every 100 hours of running time unless it has been necessary to use highly leaded fuel or oil diluted with kerosene, then change oil every 50 hours of running time. Be sure to replace the oil fill cap securely to avoid air and oil leakage.

SPARK PLUGS.- Your plant will use less fuel and start easier if the spark plugs are removed and cleaned at least once each week. If highly leaded fuels are used, it may be necessary to clean the plugs more often. Use Champion No. H-9 Com. (Type A) or a comparable type made by another manufacturer when necessary to replace spark plugs.

BATTERY.- Check the level of the fluid in the battery. If necessary, add clean distilled water to bring the level to 3/8 inch above the separators. If the battery manufacturer specifies a different level, follow his recommendations. Do not overfill the battery. Be sure to cycle the batteries of the Battery Charging plants according to the battery manufacturers instructions.

AIR CLEANER.- Remove the element and cup from the air cleaner (See Fig. 18) and thoroughly clean them in gasoline or other suitable solvent. Allow the element to dry or dry out by using compressed air before replacing it. Refill the cup to the level shown in the cup with oil of the same grade used in the engine crankcase, except as noted under Abnormal Operating Conditions.

GENERAL.- Place a few drops of light lubricating oil on the joints of the governor arm to throttle linkage.

## MONTHLY SERVICE

If your plant is to be operated more than 200 hours monthly, perform the following services at the end of each 200 hours of operation.

FUEL SEDIMENT BOWL.- Close the fuel line shut-off valve and remove the bowl and screen. Clean them thoroughly in gasoline or other suitable solvent. Inspect the gasket. If it is not in good order, replace it. Replace the bowl and screen, open the fuel line shut-off valve, and inspect for leaks. Correct any found. The Battery Charging and Remote Start plants have a separate fuel tank. Remove the shut-off valve from the tank once in a while and he clean the screen.

EXHAUST SYSTEM.- Check the exhaust line from the plant at all connecting points. Tighten or replace all parts that need it.

ENGINE COMPRESSION.- Lose of compression is usually indicated when the plant is low on power and the generator does not produce its rated output. The best way to tell if the compression is poor is to uee a compreseion gauge. If you do not have a compression gauge, oheck the compression of each cylinder by turning the engine flywheel slowly by hand. If the compression is good, quite a little effort will be needed to rock the flywheel past the compression stroke. Loss of compression may be due to leaking spark plugs, spark plug gasket, valves, cylinder head gaskets or piston ringe. Repair or replace as needed. Turn to the paragraph on COMPRESSION READINGS in the Meintenance and Repair section for further instructions.

CARBON.- Remove the cylinder heads and scrape the heads, pistons, and valves clean of any carbon formation. Use a putty knife or eimilar tool. Remove carbon every 250 operating houre unless you find from experience that your plant needs it more often. Inspect the cylinder head gaekets before installing them. Replace the gaskets if they are not in good condition.

BREAKER POINTS.- Remove the cover from the breaker box and inspect the breaker points. If the points appear to be burnt or pitted and are not too bad, they can be dressed with a fine etone and continued in service. If the points do not look serviceable, install a new set. Adjust the breaker point gap to 0.020 inch at full separation after dressing the points or changing them. Place a drop of light lubricating oil on the breaker cam pivot after installing new points. For further instructions see TIMING THE IGNITION in the Maintenance and Repair Section.

If exceesive arcing occurs at the breaker points or the breaker points continually burn over or the spark at the points is a yellowish color, it is a fairly good indication that the ignition condenser ie faulty and it should be replaced.

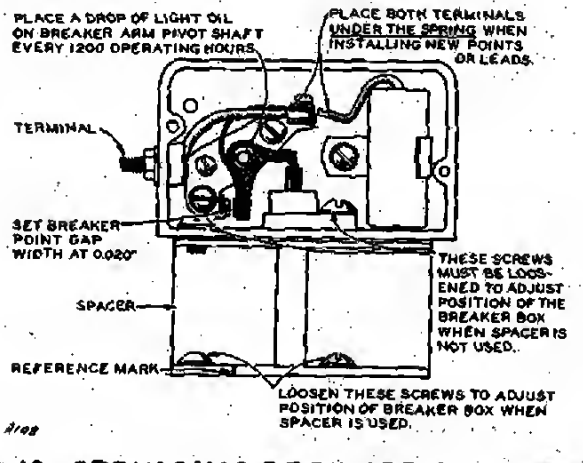



FIG. 19-SERVICING BREAKER POINTS

GENERAL CHECKUP.- Check your plant for loose bolts, nuts, screw, electrical connections, etc. Tighten or replace as needed

VALVE GRINDING.- Valve grinding is a service that should be done if your plant is to continue running efficiently. There is no set period for grinding the valves. However, it is recommended that you make the following tests at the end of each 250 hours of running time or whenever your plant begins to lose power or to use more fuel or oil than it normally does.

Check the compression of each cylinder with a reliable compression gauge while the engine is still warm and as soon after stopping the engine as you can. The compression of each cylinder in a new engine at sea level is about 85 lbs at hand cranking (95 lbs elec. cranking) speed. Compression readings of the cylinders should be within 10 lbs of each other and high enough to assure no loss of power. A low compression reading may point to either a poor valve condition or to worn or sticking piston rings, worn piston ring grooves or worn cylinder walls. An excessively high compression reading may point to a heavy carbon formation within the cylinders.

After the first readings have been taken, remove the spark plugs and pour only enough SAE number 50 oil into each cylinder to seal the rings. Then take the compression readings again. If the readings remain about the same, the valves probably need servicing. However, if the readings have increased quite a bit, the valves are probably in good condition and loss of compression may be due to worn or sticking piston rings, worn piston ring grooves or worn cylinder walls. Follow instructions given in the Maintenance and Repair section when making repairs.

If a compression gauge is not available, turn to the heading ENGINE COMPRESSION in this section for instructions on testing compression without a compression gauge.

GENERATOR.- Examine the collector rings, commutator and brushes. The brush surfaces of the collector rings and commutator must be smooth and cylindrical to assure good brush contact. Brushes worn to 5/8 inch in length should be replaced. Rapid brush wear may be caused by excessive arcing, due to the brushes not being in the neutral position. Instructions for servicing are given under the heading GENERATOR in the Maintenance and Repair section.

## SEMI-YEARLY SERVICE

If your plant is to be operated more than 1200 hours semi-yearly, perform the following services at the end of each 1200 hours of operation.

BREAKER ARM PIVOT SHAFT.- Remove the breaker box cover and place a drop of light lubricating oil on the breaker arm pivot shaft to prevent the arm from sticking. See Fig. 19.

CARBURETOR.- Remove the air inlet from the carburetor and inspect the venturi. If there are any carbon deposits on the venturi, the carburetor should be removed from the plant and thoroughly cleaned.

ARMATURE BEARING LUBRICATION.- Renew the armature bearing grease. Some generators have a large plug in the armature bearing hub. Clean all dirt from around the plug and pry out the plug. Other generators have an end cover held in place by two screws.

Remove the end cover for access to the bearing. With a clean finger remove all the old grease and work approximately one tablespoonful of new bearing lubricant into the bearing. Again clean the bearing and refill about 1/2 full, packing the lubricant well into the lower half of the bearing. See Fig. 20. Use only a good ball bearing lubricant such as supplied with the plant. Take care to avoid getting any dirt into the bearing. Replace the bearing cover or the plug, as the case may be.

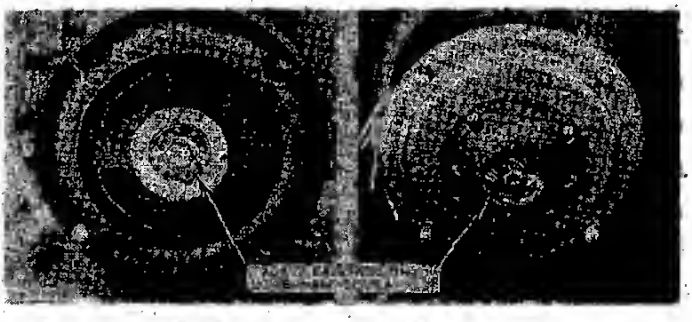


FIG. 20-SERVICING THE ARMATURE BEARING

NEUTRAL BRUSH POSITION.- Check the generator brush rig to see that it has not moved from its original position, changing the neutral position of the brushes, resulting in excessive arcing of the brushes and rapid brush wear.

Markings were made at the factory to indicate the "neutral brush position". These markings are shown in Fig. 21. Two different methods of mounting the brush rig on these plants are used and both are shown in the illustration. Select the one that applies to your plant and proceed as follows.

If the brush rig is mounted as shown in Fig.21A, the location of the "neutral brush position" mark is indicated by yellow paint on the brush rig ring near one of the mounting screws. This mark should be in the position shown in the illustration. If it is not, loosen the brush rig ring mounting screws and shift the whole brush rig assembly as needed to align the mark. Tighten the mounting screws securely.

If the brush rig is mounted as shown in Fig. 21B, the "neutral brush position" markings are located on the bearing hub and the end bell. These marks should be in alignment. If they are not, loosen the four screws in the hub and shift the hub and brush rig as needed to align the marks. Tighten the mounting screws securely.

CAUTION

If a new armature or brush rig is installed, the "neutral brush position" must be relocated and remarked. Neutral brush position is that point at which no arcing of the brushes occurs. If a voltmeter is available, the brush rig should be set at the point where highest voltage is generated. If a voltmeter is not available, set the brush rig at the point where the brushes show the least arcing.

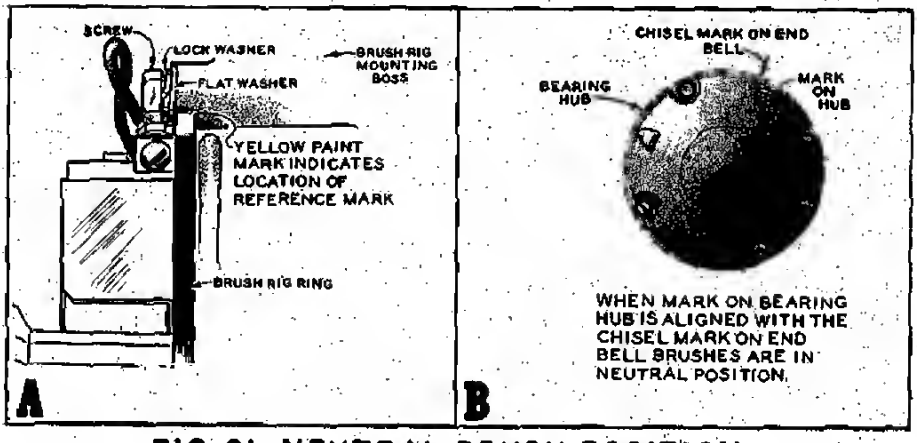



FIG. 21-NEUTRAL BRUSH POSITION

GENERAL.- This section also includes instructions for making adjustments which are not really of an accessory nature but which you should be able to make if necessary. If trouble occurs, try to find out what is causing the trouble before making any adjustments. Many possible causes of trouble and their remedies are given in the Troubles and Remedies section. If trouble occurs, turn to this section and read it carefully. It may save you time and trouble in corrscting the trouble.

CARBURETOR ADJUSTMENTS.- The carburetor has adjustable main and idling jets. It is simple in construction and normally needs little attention other than a good cleaning once in a while. If the engine runs unevenly at half or full load due to faulty carburetion, the main adjustment needs correcting. See Fig. 22. Adjust while the plant is running at normal operating temperature and carrying almost a full load. Turn the main adjusting needle out about two full turns. Then slowly turn it in until the engine begins to lose power and speed. Then turn it out very slowly until the engins runs at maximum power and speed.

The engine should be running at normal operating temperature and carrying no load when adjusting the idle jet needle. See Fig. 22. Turn the needle in until the engine loses considerable speed. Then turn the needle out until the engine runs smoothly. The correct setting is about 3/4 to 1 turn open.

If the carburstor is entirely out of adjustment, open both needles about 1-1/2 turns to permit starting. Make final adjustments as described in the above paragraphs after the engine reaches normal operating temperaturs.

When the engine is not running, the throttle should bs held wide open by the governor. In this position the throttle arm should rest against the boss on the underside of ths carburetor.

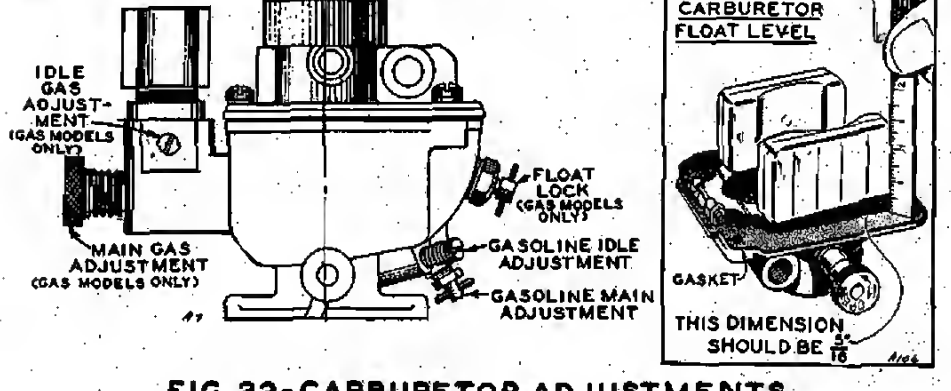



FIG. 22 - CARBURETOR ADJUSTMENTS

If the engine develops a hunting condition (continuous increase and decrease of engine speed), try correcting by opening the main adjusting needle a little more. Do not open more than 1/2 turn beyond the maximum point of power. If this does not correct the condition, follow the instructions given for regulating the sensitivity of the governor under GOVERNOR ADJUSTMENT.

Loss of power or uneven operation may be due to carbon deposits on the venturi of the carburetor. If inspection shows this condition exists, remove and clean the carburetor. Clean the jets and jet passages with compressed air or with a strand of fine soft copper wire, never with a needle or steel wire. Adjust the carburetor after the engine reaches normal operating temperature.

GOVERNOR ADJUSTMENT.- Proper governor adjustment is one of the most important factors in maintaining the proper frequency of current under different load conditions. The governor of the a-c plants is set at the factory for a maximum no-load engine speed of 1890 r.p.m. for the 60 cycle plants and 1590 r.p.m. for the 50 cycle plants. This setting should be maintained at all times. Before making any adjustments on the governor, carefully study the following paragraphs and then check each point in the order given.

D.C. Plants Are Set for Rated Voltage.

1. Governor Arm and Linkage - Throttle Shaft and Lever

Check the governor arm and linkage and the throttle shaft and lever for a binding condition and for excessive slack or wear at connecting points. A binding condition at any point will cause the governor to act slowly and regulation will be poor. Excessive looseness will cause a hunting condition and regulation will be erratic. Work the arm back and forth several times by hand while the plant is idle. If either of the described conditions exist, find out at which point the trouble lies and adjust or replace parts as needed.

a. Governor arm and linkage

The linkage and the position of the governor arm must synchronize the travel of the governor and the throttle plate so that the governor is at its wide open position when the throttle plate is at the wide open position. The governor should also be at its closed position when the the throttle plate is at its closed position.

The position of the governor arm on its shaft is fixed. Turn the governor arm toward the carburetor until the governor shaft yoke is against the governor cup. See Fig. 24. Then with the tension of the governor speed adjusting spring holding the arm at the wide open position, adjust the governor arm linkage to hold the throttle lever at the wide open position. Be sure there is no looseness or binding at any point.

b. The carburetor idle stop screw should be adjusted with the plant operating at no load, after all other carburetor and governor

adjustments are properly made. Turn the idle stop screw in until it just touches the carburetor body projection, but do not turn in far enough to increase the no load speed. Then back out the screw approximately one turn, so that the screw end clears the carburetor stop projection by 1/32". See Fig. 23.

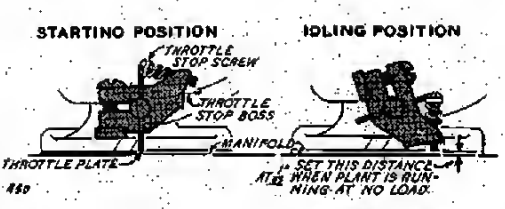



FIG. 23-THROTTLE STOP LEVER POSITION

If the plant is being run with the throttle held in the wide open position, either the governor is not properly adjusted or the capacity of the plant is being exceeded and proper current frequency and voltage cannot be maintained.

2. Governor Spring

Because governor springs become fatigued and lose their original tension from long usage, it may be necessary to replace the governor spring to get proper regulation. It is hard to determine whether or not a spring is fatigued. Usually if all other adjustments have been properly made and regulation is still erratic, replacing the governor spring and resetting the sensitivity and speed adjusting screws will correct the trouble.

3. Sensitivity Adjustment

The position of the sensitivity adjusting screw (See Fig. 24) controls the travel and leverage of the governor spring and determines the speed drop between no load and full load. The maximum difference should be about 90 r.p.m. Check with a tachometer. To increase the r.p.m. between no load and full load turn the sensitivity screw in. To decrease the r.p.m. between no load and full load, turn the sensitivity screw out. See Fig. 24. Engine speed should always be checked after making a sensitivity adjustment. See paragraph 4.

a. Hunting Condition

A hunting condition (engine alternately increasing and decreasing speed) may result from the r.p.m. between no load and full load being too low. Should this condition exist, turn the sensitivity screw in until the condition is corrected. A more likely cause will be a lean fuel mixture. Check the carburetor to see that it is in good operating condition and properly adjusted.

4. Speed Adjustment

The speed at which the engine runs is determined by the tension applied to the governor spring. Increasing spring tension increases engine speed and generator voltage. Decreasing spring tension decreases engine speed and generator voltage. Nominal engine speed and voltage should be as follows (Does not apply to battery charging plants).

Speed tests and voltage tests should be made when the plant is warm, running for at least one hour before the test is made.

A.C. PLANTS

Maximum no load engine speed should not be more than 1890 r.p.m. for 60 cycle plants nor more than 1590 r.p.m. for 50 cycle plants.

Maximum no load voltage should not be more than 126 volts for 115 volt circuits nor more than 252 volts for 230 volt circuits.

Minimum engine speed at full rated generator capacity should not be less than 1710 r.p.m. for 60 cycle plants nor less than 1410 r.p.m. for 50 cycle plants.

Minimum voltage at full rated generator capacity should not be less than 109 volts for 115 volt circuits nor less than 218 volts for 230 volt circuits.

Maximum speed drop from no load to full load should not be more than 90 r.p.m.

D.C. PLANTS

To adjust the governor on a d-c portable plant, use an accurate voltmeter across the output leads, in parallel connection with the electrical load. Start the plant and with no load connected adjust the speed adjusting nut, Fig. 24, to the point where the voltmeter shows approximately 118 volts for a 115 volt plant. Apply a full load to the plant and again observe the voltmeter reading, which should be approximately 113 volts. Voltages will of course be correspondingly higher for a 230 volt plant. If the voltage drop between no load and full load is much more than 5 volts, adjust the sensitivity adjusting stud to move the end of the spring a little closer to the center of the governor arm shaft. If the plant tends to hunt (alternately increase and decrease speed) at any load or if the voltage increases when a load is applied, decrease the sensitivity by turning the sensitivity stud out to move the spring farther from the governor shaft. Any change in the sensitivity adjustment will require a compensating change in the speed adjustment.

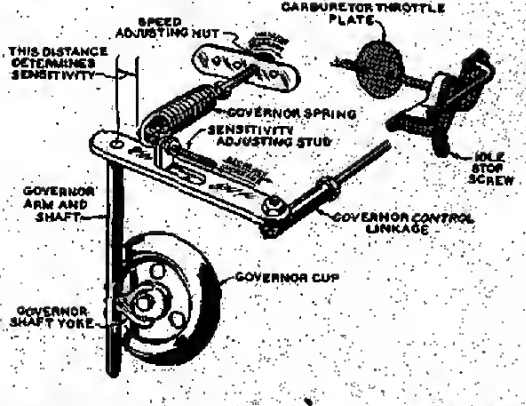



FIG. 24 - GOVERNOR ADJUSTMENT

If an adjustment is needed, turn the speed adjusting screw nut in to increase engine speed and generator voltage or out to decrease them. See Fig. 24. Be sure the knife edges of the nut fit into the slots in the governor spring bracket. NEVER INCREASE ENGINE SPEED TO INCREASE THE CHARGING RATE TO THE BATTERY OF REMOTE CONTROL PLANTS. These are basically alternating current plants and must be operated at the right speed to get proper current frequenty.

5. Steps to follow in adjusting the governor.

A. Check the position of the governor arm and the throttle lever stop. Make adjustments as described in paragraph 1 if needed.

B. Check the connecting linkage. Make adjustments as described in paragraph 1 if needed.

C. After the governor arm, throttle lever stop, and linkage have been carefully adjusted, start the plant and check the r.p.m. at no load. Correct as described in paragraph 4 if needed. (NOTE: Engine speed of battery charging plants varies with the charging rate.)

D. When all other adjustments have been completed, check the r.p.m. between no load and full load. Make adjustments as described in paragraph 3 if needed.

CRANKCASE BREATHER VALVE.- A partial vacuum is created in the engine whenever the engine is running. The work of the crankcase breather valve is to help maintain this partial vacuum and prevent oil leakage. If your engine begins to leak oil, the check valve in the breather tube may be sticking. Loosen the carbu-

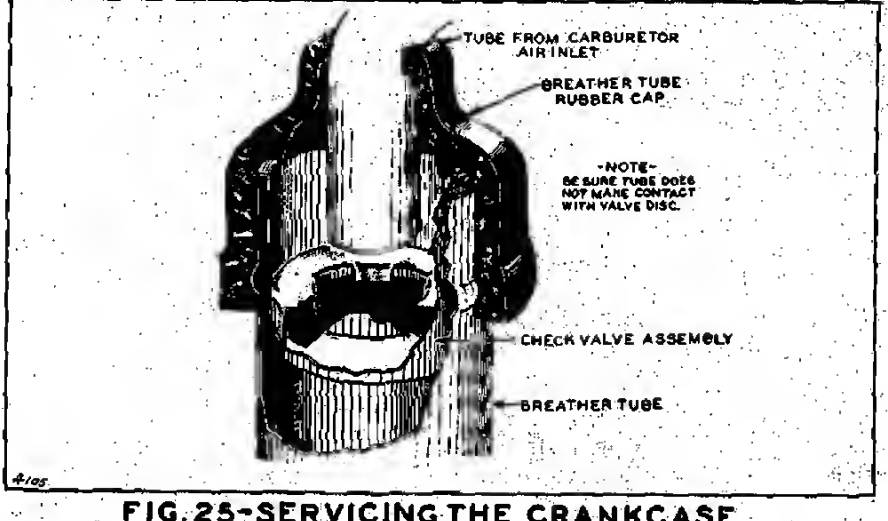



FIG. 25-SERVICING THE CRANKCASE BREATHER VALVE

retor air inlet mounting screw and remove the air inlet from the carburetor and breather tube cap. Then remove the rubber cap and the check valve from the breather tube. Inspect the check valve carefully. If the disc is stuck or does not work freely, put it in a small amount of kerosene or other suitable solvent and let it soak a few minutes. Work the disc back and forth with your fingers a few times to allow the solvent to reach all points. Then place the valve in the breather tube, hold it in place with your fingers, and start the engine. If the action of the valve is free and easy, continue to use it. Otherwise, put in a new check valve. Be sure you replace all parts that were removed.

OIL PRESSURE.- The oil pressure relief valve adjusting screw should ordinarily not be disturbed. See Fig. 26. However, if the engine suddenly develops low or high oil pressure, the relief valve may have become stuck open or closed. Remove the adjusting screw, spring and plunger and clean thoroughly in a good solvent. The oil pressure may be checked by connecting an accurate oil pressure gauge to the side of the crankcase after first removing the 1/8" pipe plug shown in Fig. 26. The oil pressure should register within a range of 15 lbs. to 25 lbs. when the engine is running at normal speed and at operating temperature. Oil pressure may be increased by turning the adjusting screw farther into the crankcase. Turning the adjusting screw outward will decrease the oil pressure. Be sure the lock nut is tightened after making any adjustment. Do not change the setting until first checking for loose bearings, incorrect oil, dirty oil pump screen, obstructed passages, etc.


FIG. 26-OIL PRESSURE RELIEF VALVE ADJUSTMENT

FUEL PUMP.- A fuel pump of the diaphragm type is used to transfer fuel from the fuel tank to the carburetor. If fuel does not reach the carburetor, make the following checks before removing the fuel pump. Check the fuel tank to see that there is enough fuel in it and the shut-off valve is open. Disconnect the fuel line at the carburetor and turn the engine over slowly by hand. Fuel should spurt out of the line at the carburetor. Disconnect the line at the fuel pump inlet and see that this line is not plugged. If there is enough fuel in the tank, the shut-off valve open, and the line between the tank and pump is clear but gas does not spurt out of the line at the carburetor, repair or replace the pump. Fuel pump failure is usually due to a leaking diaphragm, a valve or valve gasket; a weak or broken spring; or wear in the driving

linkage. See the Parts List for an illustration of the pump. Should a new driving link be needed, install it as shown in Fig. 24, the end of the link encircling the shaft.

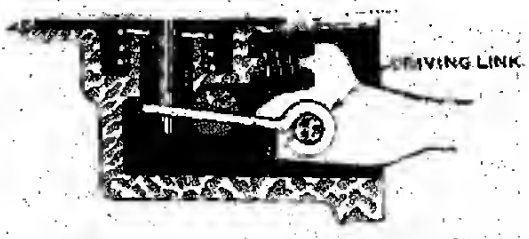



FIG.27-FUEL PUMP DRIVE LINK INSTALLATION

ELECTRIC CHOKE ADJUSTMENT.- Remote Control and Battery Charging plants are equipped with an electric choke which consists mainly of a nichrome heating element and a bi-metal thermostat. This bi-metal thermostat is attached to the choke shaft and works the choke plate. If the choke is operating OK don't change the adjustment in any way. Once the choke is properly adjusted it shouldn't need changing.

As soon as the START button is pressed in, current begins to flow from the battery to the heating element. The battery supplies the current during the starting period. After the plant is started, current is supplied from the series field winding of the generator until the plant is stopped.

The bi-metal thermostat opens and closes with temperature changes. The heat from the heating element tends to open the choke plate until it is fully open. The heat from the element then tends to keep it in the open position as long as the plant is running. After the plant is stopped the bi-metal thermostat cools off and gradually closes the choke plate. The choke plate will not close entirely when the plant is stopped unless the temperature at the thermostat drops to 58° F. or below. At 58° F. the choke plate should be fully closed. At 72° F. the choke plate should be about half way open. At 82° F. the choke plate should be fully open. See Fig.28.

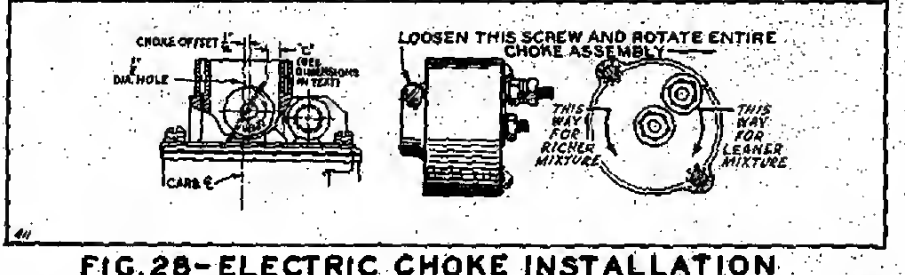



FIG.28-ELECTRIC CHOKE INSTALLATION

If your plant is hard to start or runs poorly when temperatures at the plant drop to 32° F. or below, it may help to change the choke setting. Check engine starting time before making any changes. The engine should be cold when making the test, not run for several hours. Then proceed as follows:

1. Press the START button. If the engine fires and begins to run in not less than 6 seconds and not more than 15 seconds, the choke is properly adjusted.

2. If the engine fires in less than 6 seconds, the choke is set too rich. This will cause the plant to run rough after a minute or two of operation.

3. If the engine does not fire within 15 seconds, the choke setting is too lean. This will cause hard starting and the engine will sputter and spit until it warms up or it may quit entirely after a few seconds of running.

The choke adjustment is easily and simply changed. Just loosen the choke bracket mounting screw and turn the entire choke assembly clockwise on the shaft for a leaner fuel mixture or counterclockwise for a richer fuel mixture. Be sure to tighten the mounting screw securely after making an adjustment.

For best results the choke should be set according to the figures given in the following table.

| TEMP °F. | OPENING "C" (Fig. 25) |
|---|---|
| 58 | Closed |
| 66 | 1/4 Open |
| 72 | 1/2 Open |
| 76 | 3/4 Open |
| 82 | Wide Open |

For a choke setting at temperatures below 32° F., a "cut and try" method must be used. Turn the choke assembly clockwise until the choke plate just starts to move away from its fully closed position and there is no tension on the thermostat. Then secure the choke to the shaft and try starting the engine. Check starting time as described in a preceding paragraph. Change the choke adjustment as necessary to get proper operation.

Once the choke is properly set no further adjustment is required nor should any be made, the exception being for cold weather operation.

GENERAL.- Certain new engines when leaving the factory have an oversize cylinder bore. This oversize is indicated by the addition of a letter to the plant serial number. For example: Serial No. 48. 382425E, the letter E indicating .005" oversize. Also the oversize is stamped on a flat metal surfsce near the left hand valve box. The pieton oversize is stamped on top of the piston. If oversize valve seat inserts have been used, the actual oversize will be stamped on the cylinder block bevel just above the insert.

Pistons and rings are available in various oversizes for rebore jobs. See the parts list. Piston pins and valve seat inserts are also available in the oversizes shown in the parts list. Before ordering any repair parts that may be needed in an oversize, check the serial number of your plant and the positions of the oversize stampings as noted above.

## ENGINE

CYLINDER BLOCK INSPECTION.- The need for major repairs to your plant can usually be determined, after draining the oil, by removing the oil bass and feeling the fits of the working parts. Also by using a trouble lamp and carefully looking over the inside of the crankcase. If your experience with engines is limited, any competent mechanic should be able to help you decide on the need for repairs. Drain the oil whenever servicing bearings, timing gears, rods, rings, or pistons. Thoroughly clean the oil pump screen and oil base before replacing the base.

COMPRESSION READINGS.- Loss of power, failurs of the plant to produce its rated output, may point to a lose of compression. See VALVE GRINDING under Periodic Service for testing compression. Loss of compression may be due to leaking spark plugs, spark plug gaskets, valves, cylinder head gaskets, carbon deposits on valve seats, worn cylinders or piston rings. A compression leak past the piston rings may be heard at the oil filler opening. Compressed gases leaking past an exhaust valve can be heard at the exhaust outlet of the plant. If compressed gases are leaking past an intake valve, a hissing noise may be heard through the carburetor. If any valve is leaking, all valves should be serviced. Unusually high compression readings point to heavy carbon deposits on the cylinder heads and pistons. Remove the cylinder heads and scrape the carbon from the pistons, cylinder heads, and valves.

CYLINDERS.- When making major repairs to your plant, it is well to have the cylinders measured for wear. This requires the use of a micrometer. Your dealer should be able to help you. The cylinder bore of a new engine is 2-1/2 inches plus or minus .005 inch. If the new engine was bored to oversize originally, the bore will be .005 inch over. If the cylinder bore measures more than .005 inch out of true, the cylinders should be refinished to use the next available oversize pistons. Pistons are available in .005, .010, .020 and .030 inch oversize. Piston rings are available in .010, .020 and .030 inch oversize. Use standard rings with .005 inch oversize pistons.

If the cylinder walls do not need refinishing, it is advisable to remove the ridge from the top of the cylinder sleeve before replacing the pistons and rings. Also read the following paragraph on PISTON AND PISTON RING SERVICE.

PISTON AND PISTON RING SERVICE.- Each piston has two compression rings and one oil control ring. Inspect the rings carefully for fit in grooves, for tension, and for seating on cylinder walls. If there is any doubt about the condition of the old piston rings, install new rings.

Inspect each piston. If the pistons are badly scored, very loose in the cylinders, have badly worn ring grooves, or otherwise are not in good condition, install new pistons. Install new pistons if the old ones are loose on the piston pins and .005 inch oversize piston pins will not correct it. Handle pistons carefully to avoid nicking the walls. Any raised surface of this type must be dressed down carefully with a fine file. Piston to cylinder clearance is .003" to .0045".

When installing piston rings, fit each ring singly to its cylinder from the top. See Fig. 29. The correct ring gap while in the cylinder is between .008 and .017 inch. Rings usually need some filing at the ends to obtain the right gap. Don't use rings that need a lot of filing as they will not seat properly on the cylinder walls. Install the rings on the pistons. Rings of the tapered type will be marked "TOP", or identified in some other manner, and this identifying mark must be placed nearer the top of the piston. Space each ring gap 1/3 of the way around the piston from each other, being sure no ring gap is directly in line with the piston pin.


FIG.29-FITTING PISTON RINGS TO THE CYLINDER

CONNECTING RODS.- Should it become necessary to remove the connecting rods for any reason, the numbers on the connecting rod and cap must face the oil base when reassembling. Install the bearing cap and rod numbered "1" on the crankshaft journal nearest the flywheel. The clearance between the connecting rod bearing surface and the crankshaft bearing surface should be between .0015" and .0035 inch. If necessary the

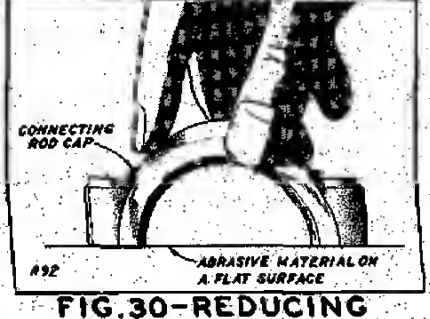



FIG.30-REDUCING CONNECTING ROD CLEARANCE

clearance can be reduced by carefully dressing the connecting rod cap. Use a suitable abrasive placed on a smooth flat surface. Be sure to remove all abrasive from the cap before installing it.

VALVE SERVICE.- The cylinder heads must be removed from the plant whenever servicing the valves. When removing the cylinder heads, rap sharply with a soft hammer to loosen. Do not use a pry. Remove the valves, valve springs, retainer washers, and valve guides. See Fig. 31.

Clean all carbon from the cylinders, cylinder heads, valves, valve seats, valve stems, valve faces and valve guides. Check the valves carefully. Any valves that are badly burned must be replaced. Valve seats and valve faces must be at a 45° angle. The finished seat must be between 3/64 and 5/64 of an inch wide. Before lightly grinding each valve to its seat, read the paragraph on VALVE ADJUSTMENT. Be sure to remove all grinding compound from engine parts. Locate each valve in its proper place when reassembling. The larger valves are the intake valves.

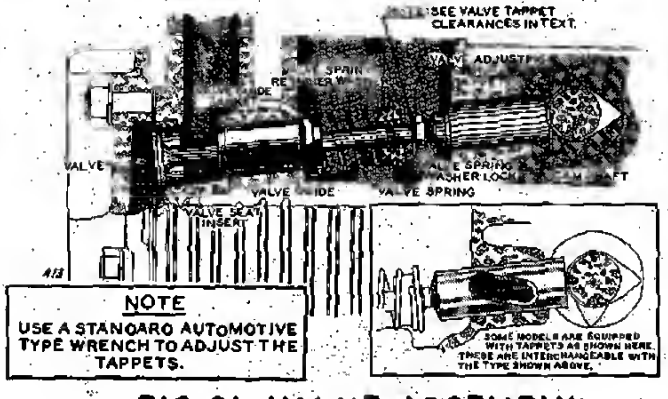



FIG. 31 - VALVE ASSEMBLY

VALVE ADJUSTMENT.- To make a valve adjustment, remove the valve covers. Then crank the engine over slowly by hand until the left hand intake valve, when facing the flywheel, opens and closes and continue about 1/4 turn until the "TC" mark on the flywheel and the mark on the gear cover are in line. This should place the left hand piston at the top of its compression stroke, the position it must be in to get proper valve adjustment for the left hand cylinder. Clearances given are for room temperature, (72° F., 22° C.). Use .006 and .008 inch feeler gauges. In each case the thinner gauge should pass freely between the valve stem and valve tappet but the thicker gauge should not.

FIG. 32 - CHECKING VALVE CLEARANCE

To correct the valve clearance, simply turn the adjusting screw as needed to obtain the right clearance. The screw is self-locking and will stay where set.

If valve clearance can no longer be held within given limits, replace the valve.

To adjust the valves of the right hand cylinder, crank the engine over one complete revolution and again line up the "TC" mark on the flywheel and the mark on the gear cover. Then follow the adjustment given for the valves of the left hand cylinder.

FLYWHEEL.- Before the flywheel can be removed, all parts necessary to expose the flywheel must be removed. Then turn the flywheel mounting screw out two full turns, insert a screwdriver between the flywheel and the gear cover to take up crankshaft end play and strike a sharp endwise blow on the head of the cap screw with a heavy soft hammer. Remove the flywheel carefully to avoid damaging the magneto stator assembly. Do not drop the flywheel. A suitable puller can easily be made from a piece of bar steel and the flywheel removed with the aid of the puller, if so desired.

When replacing the flywheel be sure the key is in place on the crankshaft. Then install the flywheel. Install the mounting capscrews and tighten to 45 to 55 pounds feet torque. Replace other parts removed, reversing the order in which they were removed.

GEAR COVER.- All parts necessary to remove the flywheel must be removed, including the flywheel, before the gear cover can be removed. Then disconnect the linkage and the spring from the governor arm, take out the gear cover mounting screws and remove the gear cover. Tap the gear cover gently with a soft hammer to loosen it.

When replacing the gear cover, turn the stop pin on the governor cup to the point where it agrees with the 9 o'clock position on the face of a clock. See Fig. 33. Then turn the governor arm and shaft clockwise as far as it will go and hold it in this position until the gear cover is


FIG. 33- REPLACING GEAR COVER

flush against the cylinder block. The governor cup stop pin must fit into the slot in the governor shaft yoke. See Fig. 33. Turn the governor arm and shaft counterclockwise as far as it will go and gently lift up on the arm. If the pin is in place, the governor arm and shaft will not pull out more than 1/2 inch. If they pull out more than this, the pin is not in place and the gear cover must be removed and the installation repeated.

GOVERNOR CUP.- With the gear cover removed, the governor cup can be taken off by removing the snap ring from the camshaft center pin and sliding the cup off. Be sure to catch the flyballs as they will fall out when the cup is removed.

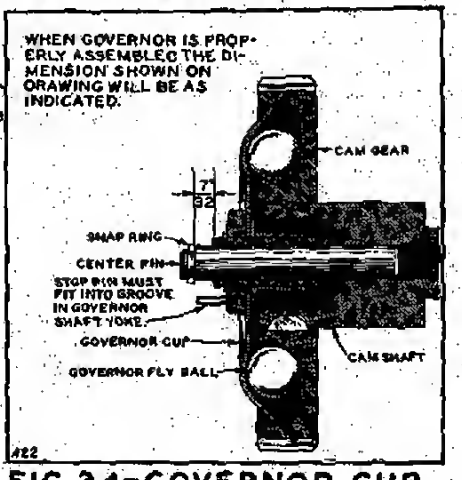



FIG. 34-GOVERNOR CUP ASSEMBLY

When installing a new governor cup, tip the plant upward from the engine end, place the flyballs in their places, and install the governor cup on the center pin. Then install the snap ring on the camshaft center pin. The distance from the snap ring to the governor cup sleeve, when the cup is flush against the flyballs, must be exactly 7/32 of an inch if the governor is to operate as it should. See Fig. 34. If it is less than 7/32 of an inch, remove the cup and carefully dress down the face of the sleeve until this clearance is obtained. If more than 7/32 of an inch, the camshaft must be removed and the center pin carefully pressed in by means of an arbor press to allow 7/32 of an inch clearance. See Fig. 34. Leave the cup and snap ring on the pin to measure by. Be very careful not to bend the center pin as it is not replaceable in the field.

CRANKSHAFT GEAR.- With the gear cover removed, the crankshaft gear is easily removed. A suitable gear puller may be used or on certain plants the gear is drilled and tapped and the gear can be removed by using two number 10-32 screws and turning them in until they butt up against the crankshaft and push the gear off. If a puller is used and the gear is to be used again, apply the puller carefully to avoid damaging the teeth.

When replacing the camshaft gear, use a hollow pipe that will fit over the crankshaft but will not hit the teeth of the gear and press the gear on to the shoulder on the shaft. Be sure the woodruff key is in place.

Should it be necessary to replace the crankshaft gear at any time, the camshaft gear must be replaced at the same time as the gears are matched and are sold only in sets.

CAMSHAFT AND GEAR ASSY.- The camshaft and gear should be removed from the plant as an assembly. Before this can be done the gear cover, lock ring and special washer on the crankshaft, the ignition breaker box and plunger, the fuel pump and the valve stem locks must be removed. Pull the valve tappets into the box. Then slide the camshaft and gear out as an assembly.

If the gear is to be removed from the shaft, remove the snap ring from the center pin, the governor cup and the flyballs. Then place the camshaft and gear in an arbor press and remove the gear. Be very careful not to damage the center pin as it is not replaceable in the field.

If the camshaft gear is to be replaced, the crankshaft gear must also be replaced as they are sold only as a matched set. When pressing the camshaft gear into place on the shaft, be sure the key is in place and the gear is straight on the shaft.

When replacing the assembly in the block, be sure to use a thrust washer of the right thickness behind the gear to allow .003 to .005 inch endplay. This end play can easily be checked by pushing in on the assembly and using feeler gauges to check the gap between the camshaft gear and the crankshaft gear washer. The thinner gauge should slide easily between the two parts but the thicker gauge should not. Be sure the timing marks on the camshaft gear is lined up with the timing mark on the crankshaft gear as shown in Fig. 35.

TIMING GEARS.- The crankshaft gear and the camshaft gear form the timing chain. These gears are matched and are sold only in sets. Should either gear need replacing, both gears must be replaced. When installing new timing gears or replacing the old timing gears, the timing marks must be aligned as shown in Fig. 35.

FIG. 35 - TIMING GEAR ASSEMBLY

CRANKSHAFT.- The plant must be completely disassembled to remove the crankshaft. Whenever making major repairs on the engine always inspect the drilled passages of the crankshaft and if necessary, clean them to assure proper lubrication of the connecting rods. Also the bearing journals should be inspected. If they are scored and cannot be smoothed out by dressing down, a new crankshaft should be installed.

When replacing the crankshaft, use gaskets as needed behind the bearing plate to assure end play of .006 to .012 inch.

BEARINGS.- Removal of the camshaft and crankshaft bearings requires complete disassembly of the engine. Use a press or a suitable drive plug to remove the bearings. Drive or press the crankshaft bearings from the outside toward the inside of the cylinder block. Drive or press the camshaft bearings from the inside toward the outside of the cylinder block. Be very careful not to damage the bearing bores when removing a bearing.

The crankshaft bearings must be installed from the inside of the cylinder block with the oil holes in the bearings aligned with the oil holes in the bearing boss. Use a press or suitable drive plug to install the bearings. Press or drive both bearings in until the flange is flush with the inner end of the bearing boss. Use oil on the outer bearing surface to reduce friction. Coat the inner surface of each bearing with oil before installing the crankshaft.

The oil groove of the front camshaft bearing must be centered at the top. The oil hole in the rear camshaft bearing must be aligned with the hole in the bearing boss. Install both bearings from the outside. Press or drive the front bearing in flush with the bearing boss and the rear bearing in flush with the welch plug groove. Replace the welch plug of the rear bearing.

NOTE: The crankshaft and camshaft bearings must be line bored or line reamed after being installed in the cylinder block. The crankshaft main bearing journals should be measured with a micrometer and the bearings line bored to allow a clearance of .002 to .003 inch. The camshaft bearings should be line bored to allow a clearance of .001 to .003 inch clearance. Any reliable machine shop should be able to perform this service. If equipment for line boring or reaming is not available locally, see the dealer from whom you purchased your engine or return it to the factory for repairs.

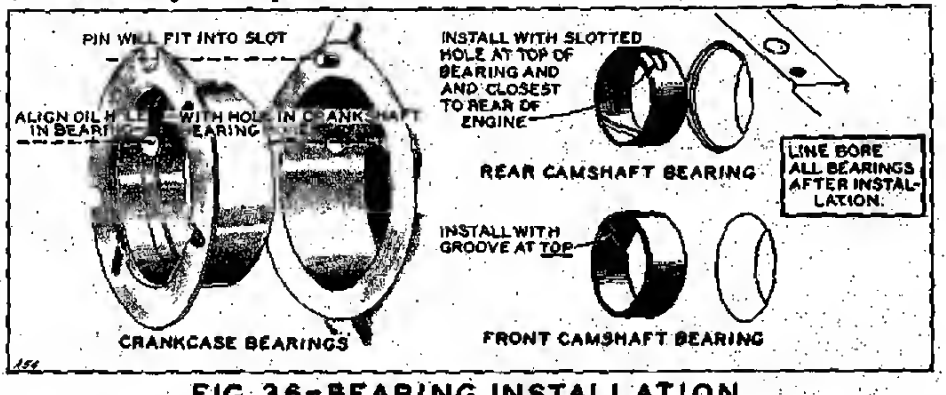



FIG. 36-BEARING INSTALLATION

FUEL SYSTEM.- Instructions for adjusting and servicing the different parts of the fuel system are given under Periodic and Accessory Service.

OIL SEALS.- The gear cover must be removed to replace its oil seal. Drive the old seal out from the inside of the gear cover.

The bearing plate must be removed to replace its oil seal. Drive the old seal out from the inside.

When installing the gear cover oil seal, tap the seal in to the limit allowed by the recess.

When installing the bearing plate oil seal, tap the seal into the bearing plate until it is flush with the outer end of the boss. After the seal is in place, it is advisable to apply a thin coating of shellac or Permatex around the outer surface of the seal at the point where is comes in contact with the bearing plate boss. Place a piece of shim stock around the end of the crankshaft when replacing the bearing plate to avoid damaging the seal. Remove the shim stock as soon as the plate is in place.

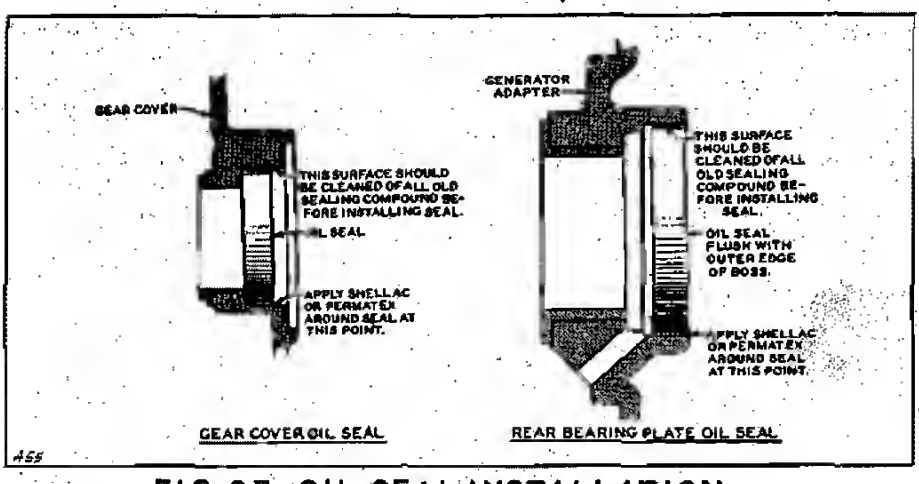



FIG. 37-OIL SEAL INSTALLATION

OIL PUMP.- The plant must be completely disassembled to remove the oil pump. Remove the pump from the cylinder block as shown in Fig. 38.

Check the oil pump thoroughly for worn parts. Should any part need replacing, replace the entire pump assembly as the oil pump is sold only as a complete unit.

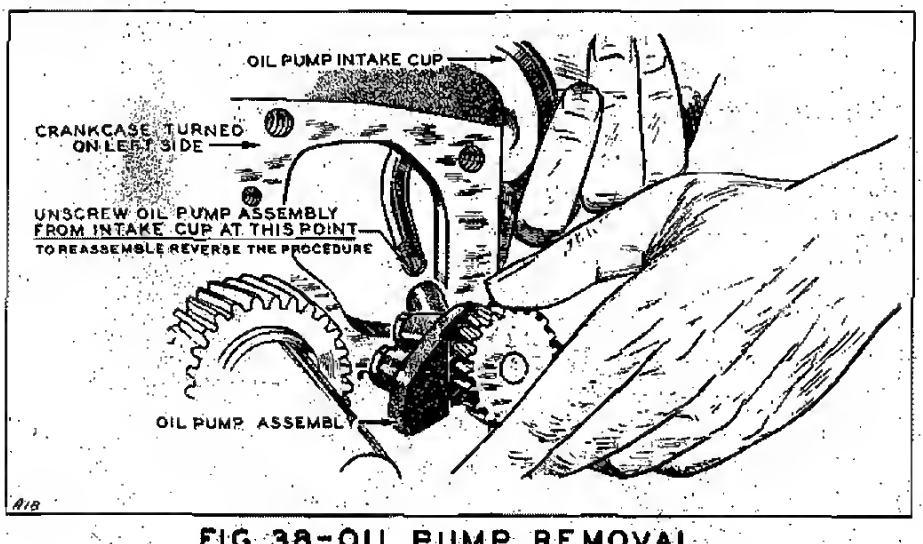



FIG. 38-OIL PUMP REMOVAL

MAGNETO STATOR INSTALLATION.- The magneto stator assembly is mounted on the gear cover and the flywheel must be removed to expose it. Fig.39 shows the stator assembly correctly installed on the gear cover. Note that there are inside and outside mounting holes. The inside mounting holes must be used to mount the stator assembly in the position shown for a 19° spark advance, the outside holes for a 25° spark advance. Connect the small coil lead to the cable clip terminal as shown. Connect the large lead to the breaker box terminal, being sure it is held in place by the clip as shown.

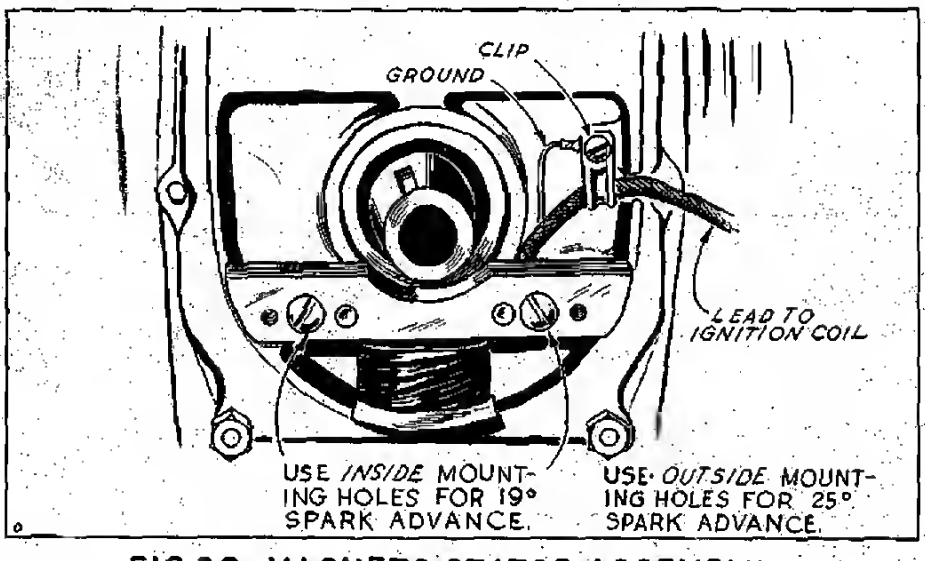



FIG.39-MAGNETO STATOR ASSEMBLY

TIMING THE IGNITION.- The spark advance is 19° before top center for remote control, battery charging and a-c portable plants and 25° BTC for the d-c portable plants. Use the correct degree mark and the "TC" mark on the flywheel for your plant and proceed as follows:

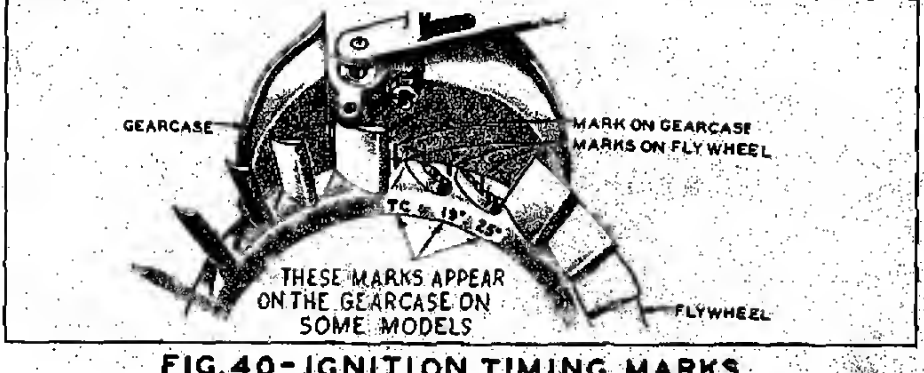



FIG.40-IGNITION TIMING MARKS

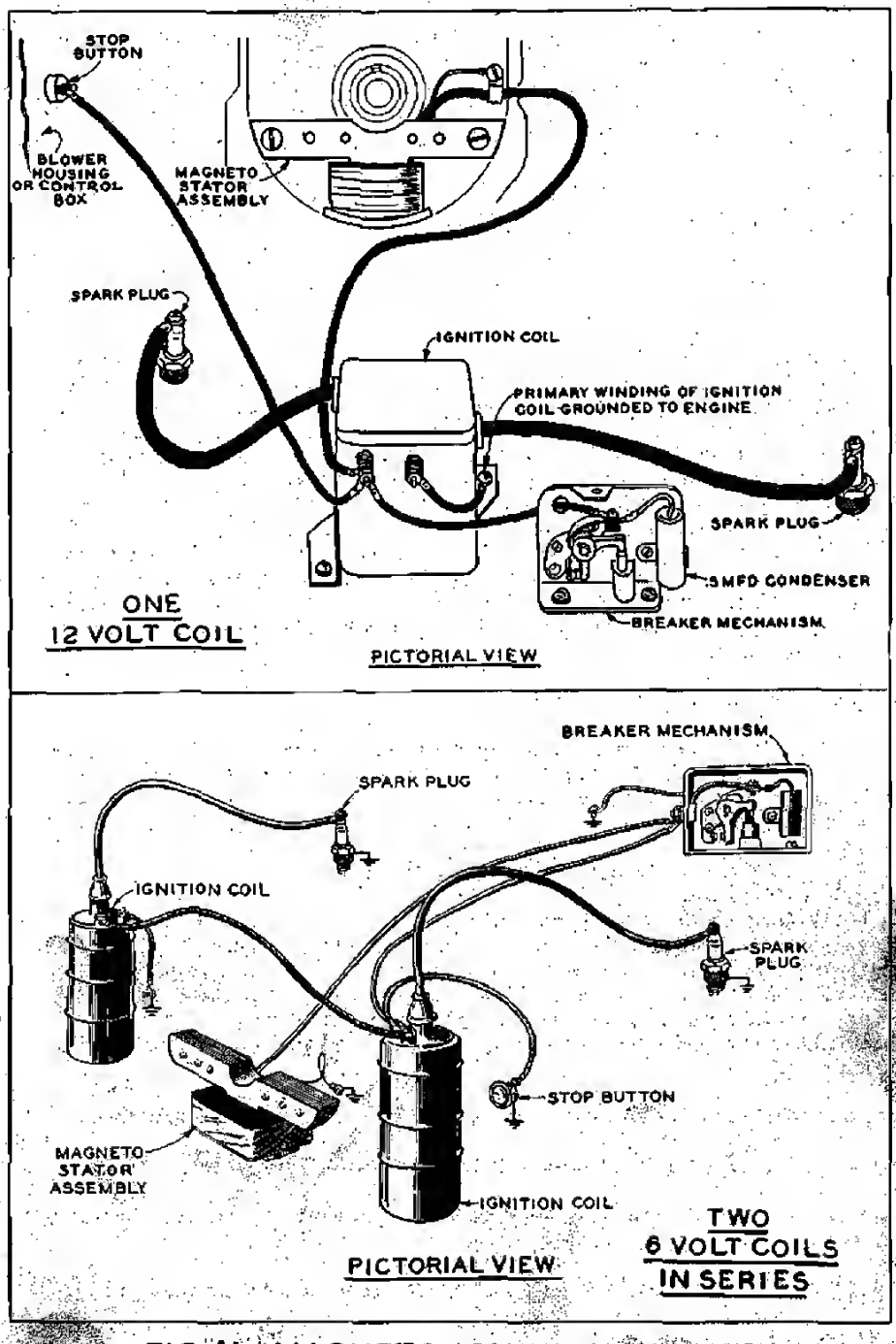



FIG.41 - MAGNETO IGNITION CIRCUIT

1. Remove the cover from the breaker box end check the witness marks on the crankcase and breaker box (or spacer). If these marks are not in alignment, loosen the breaker box (or spacer) mounting screws and align these marks. See Fig. 19. This will give a nearly correct setting of the breaker box.

2. Crank the engine over slowly by hand in the direction of crankshaft rotation until the "TC" mark on the flywheel and the mark on the gear cover are exactly in line. See Fig. 40.

3. Adjust the ignition breaker point gap width to .020 inch at full separation.

4. Turn the flywheel slowly to the right and note whether the ignition points just separate when the correct degree mark on the flywheel aligns with the mark on the gear cover. If the marks align as the points break, timing is correct. If they do not, loosen the breaker box (or spacer) mounting screws and shift the whole breaker box (and spacer) assembly to the right to advance the timing (points not breaking soon enough) or to the left to retard the timing (points breaking too soon). The witness marks on the cylinder block and breaker box (or spacer) may not be in alignment after this adjustment has been made but this is not important as these marks give only an approximately correct position of the breaker box. Tighten the breaker box (or spacer) mounting screws securely after making an adjustment.

5. Replace the breaker box cover.

GASKETS.- Always use new gaskets when replacing any part that requires a gasket. Thoroughly clean the surface that the gasket contacts before installing the gasket. Gaskets are listed singly in the Parts List and are also listed in kit form under SERVICE KITS.

## ASSEMBLY TORQUES

Assembly torques as given here require the use of a torque wrench. These assembly torques will assure proper tightness without danger of stripping the threads. If a torque wrench is not available, you will have to estimate the degree of tightness necessary for the stud or nut being installed and tighten accordingly. Do not strip the threads. Check all studs and nuts frequently. Tighten as needed to prevent their working loose.

CYLINDER HEAD STUDS AND NUTS.- Tighten to 18 to 20 feet pounds torque.

OTHER 5/16 INCH CYLINDER BLOCK STUDS AND NUTS.- Tighten to 10 to 12 feet pounds torque.
Tighten other studs and nuts just enough to assure tightness. Be careful not to strip the threads.

CONNECTING ROD BOLTS.- Tighten to 18 to 20 feet pounds torque.

FLYWHEEL CAPSCREW.- Tighten to 45 to 55 feet pounds torque.

ARMATURE THROUGH STUD AND NUT.- Tighten to 45 to 55 feet pounds torque.

## TABLE OF CLEARANCES

| | MINIMUM | MAXIMUM |
|---|---|---|
| Valve Tappet, Int. & Exh - Cold | 0.006" | 0.008" |
| Intake Valve Stem Clearance in Guide | 0.0015" | 0.003" |
| Exhaust Valve Stem Clearance in Guide | 0.003" | 0.0045" |
| Valve Seat Width | 3/64" | 5/64" |
| Crankshaft Main Bearing Clearance | 0.002" | 0.003" |
| Crankshaft End Play | 0.006" | 0.012" |
| Camshaft Bearing Clearance | 0.001" | 0.003" |
| Camshaft End Play | 0.003" | 0.005" |
| Connecting Rod Bearing Clearance | 0.0015" | 0.0035" |
| Connecting Rod Endplay | 0.005" | 0.007" |
| Timing Gear Backlash | 0.003" | 0.005" |
| Oil Pump Gear Backlash | 0.003" | 0.005" |
| Piston Clearance in Cylinder | 0.003" | 0.0045" |
| Piston Pin Clearance in Piston at 72° F. | Hand Push Fit | |
| Piston Pin Clearance in Rod at 72° F. | Thumb Push Fit | |
| Piston Ring Gap in Cylinder | 0.008" | 0.013" |
| Breaker Point Gap at Full Separation | 0.020" | |
| Spark Plug Gap | 0.025" | |

## GENERATOR

The generator normally needs little care other than proper lubrication of the armature ball bearing and a periodic check of the brushes, commutator and collector rings. If a major repair job on the generator should become necessary, have the equipment checked by a competent electrician, one who is thoroughly familiar with the operation of electric generating equipment.

GENERATOR DISASSEMBLY.- If disassembly of the generator becomes necessary, refer to the proper wiring diagram for the applicable plant and disconnect wires as necessary. Tag the wires to assure correct replacement. Lift all brushes high in their guides so that each brush is held away from contact with the commutator and collector rings by spring pressure against its side. Remove the end bell nuts from the two studs which pass through the generator frame. The frame and end bell may then be separated from the generator to engine adapter and carefully pulled off over the armature. Be careful not to allow the frame to rest or drag on the armature. Reverse the above procedure when reinstalling the frame assembly. See Figure 44. Note that a small spring clip on the armature bearing must fit into a slot of the bearing hub. Be sure the small pins on the edges of the generator frame and the adapter engage the corresponding notches in the end bell and frame. Do not retighten the stud nuts so tightly as to distort the end bell.

If the armature is to be removed, the generator frame must be removed first. Loosen the nut at the outer end of the armature shaft so that the nut is even with the end of the stud. While prying or pulling outward on the armature to take up crankshaft end play, strike the stud a sharp endwise blow with a heavy soft faced hammer to loosen the armature from the crankshaft. Remove the nut and washer and the armature can then be slipped off over the through stud. Be careful not to bend the stud. When replacing the armature, make sure the taper surfaces of the armature and crankshaft are clean and free of nicks. Tighten the through stud nut securely.

BRUSHES.- Keep a close check on the generator brushes. Brushes worn to 5/8 of an inch should be replaced. If the brushes seem to wear rapidly, check the collector rings and commutator. If they become rough or pitted or if the mica between the commutator bars comes in contact with the brushes, brush wear will be rapid. An improperly adjusted brush rig will also cause rapid brush wear. Each of these causes of brush wear are treated in separate paragraphs.

BRUSH RIG POSITION.- Check the witness mark on the brush rig and if necessary align it with the boss in the end bell as shown in Fig. 21. If the brush rig is not adjusted so that there is no arcing of the brushes (neutral brush position), brush wear will be rapid, voltage and current will not hold steady and the generator may overheat.

Whenever a new brush rig or armature is installed, the brush rig must be adjusted to the point where the brushes do not arc, regardless of where the witness mark falls. This is commonly known as the "neutral" brush position.

COLLECTOR RINGS.- If the collector rings become grooved or out of round, or the brush surface becomes pitted or rough so that good brush seating cannot be maintained, remove the armature and refinish the collector rings in a lathe. If the commutator appears to be in need of it, refinish it at the same time.

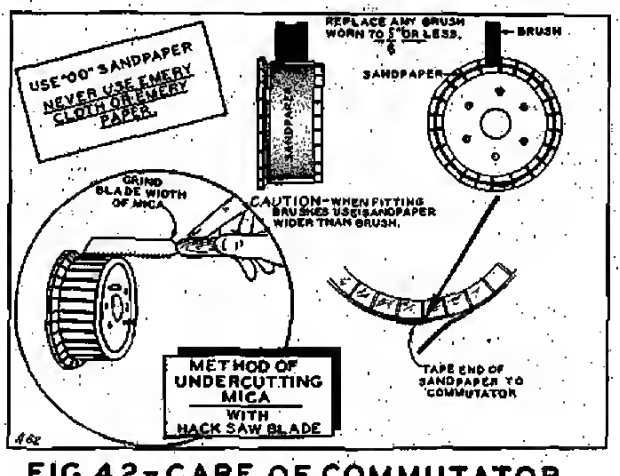



FIG. 42 - CARE OF COMMUTATOR AND BRUSHES

COMMUTATOR.- The commutator bars wear down with usage so that the mica between them must be underout. This should be done as soon as the mica on any part of the commutator touches the brushes. A suitable undercutting tool can be made from an old hack saw. Use it as shown in Fig. 42. Avoid injury to the surfaces of the copper bars. Leave no burrs along the edges of the bars. The mica must also be undercut whenever the commutator is refinished.

TESTING WINDINGS.- A test lamp set and an armature growler are required for the various tests. Before making any teste, lift all brushes into their holders and disconnect the load circuit wires from the plant. If the armature tests defective, the practical repair is to replace it. If a field coil tests defective, replace the entire coil assembly unless the trouble is in one of the external leads. Then it can be repaired as the nature of the trouble requires.

TESTING ARMATURE WINDINGS FOR OPEN OR SHORT CIRCUITS.- This test requires the use of an armature growler. The armature assembly must be removed from the plant. Then follow the instructions given by the manufacturer of the armature growler.

TESTING ARMATURE WINDINGS FOR GROUNDS.- Use a test lamp set. Touch one test prod to the armature shaft and the other to the commutator and then each collector ring. Be sure the test prods make good contact. If the lamp lights, the armature is grounded.

TESTING FIELD WINDINGS.- Use a test lamp set (See Fig. 43) for all tests except a short circuit. When testing a field coil assembly, disconnect all of its external leads from their terminals It is advisable to tag and mark each lead to assure proper connections when reassembling.

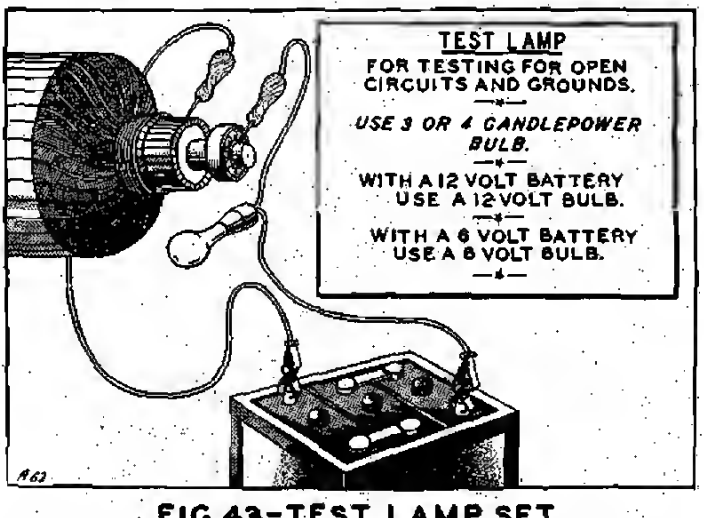



FIG.43-TEST LAMP SET

TESTING FIELD WINDINGS FOR GROUNDS.- To test a coil assembly for a ground, disconnect its external leads and touch one test prod to the terminal of one of its leads and the other test prod to the generator frame. If the lamp lights, the coil assembly being tested is grounded. The ground may be in a coil, coil connection or coil lead. Repair or replace as needed.

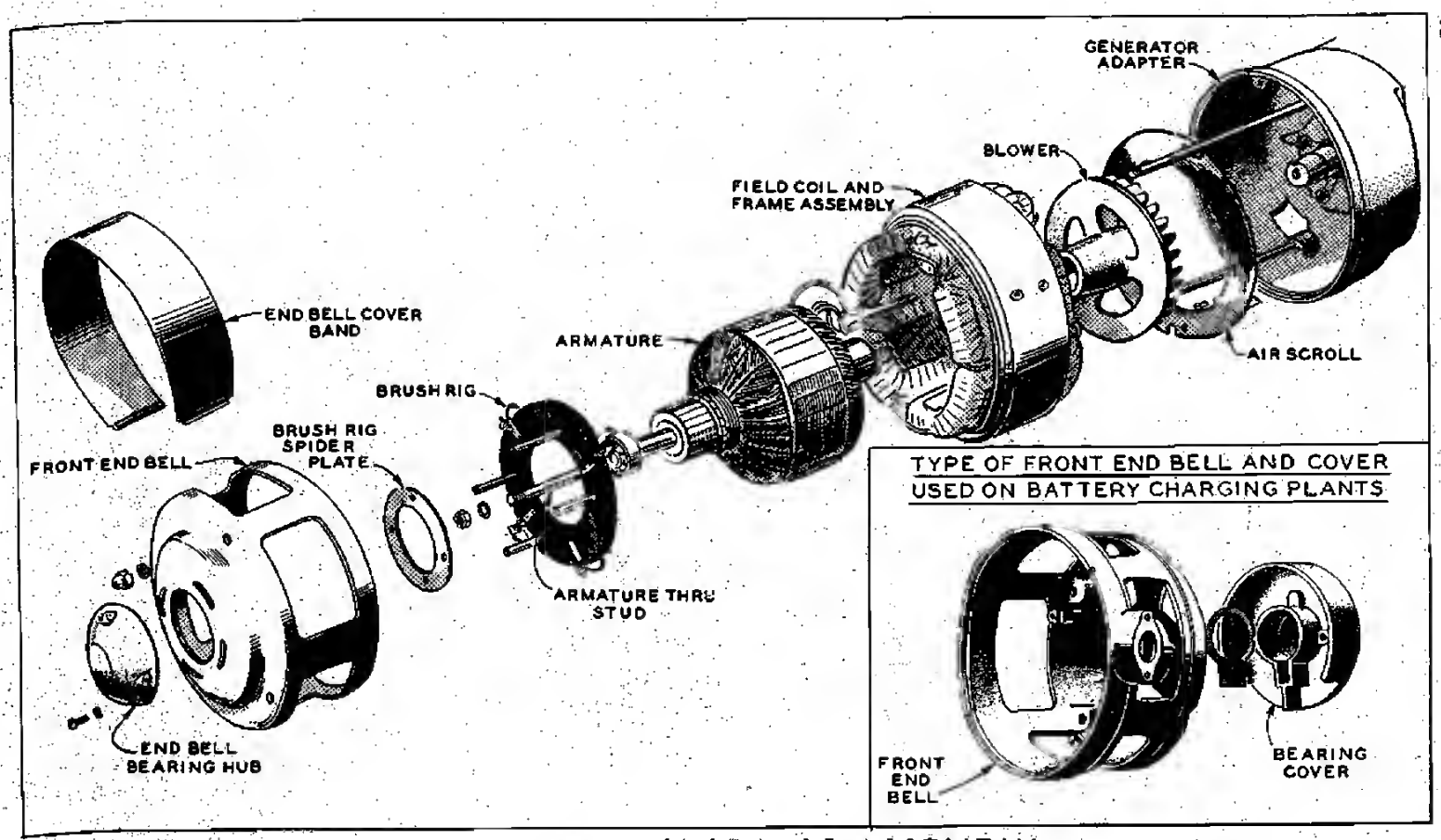



FIG. 44-GENERATOR ASSEMBLY

TESTING FIELD WINDINGS FOR OPEN CIRCUIT.- To test a coil assembly for an open circuit, disconnect its external leads and touch one test prod to the terminal of one coil lead winding and the other test prod to each of the other leads of that coil winding in turn. If the lamp does not light, the circuit being tested is open. If the fault lies in a connection between coils or in a coil lead, the trouble can be repaired. If it is inside the coil proper, replace the entire coil assembly.

TESTING FIELD WINDINGS FOR SHORT CIRCUIT.- If one coil is short circuited it will run cooler than the others and it may be possible to locate the short-circuited coil by placing your hand on the generator frame at each of the poleshoe positions and noting at which poleshoe position the frame is cooler than normal. A more definite test is a comparative resistance test or a comparative voltage drop test. If the coil windings are short-circuited replace the entire coil assembly.

FIELD COIL INSTALLATION.- The generator frame assembly must be removed from the plant before the field coils can be removed from the poleshoes. Tag and mark all external leads to assure correct connections when reassembling. When removing the poleshoes and coils be sure to keep the shims used under each poleshoe together to assure correct air gap when installing the coil assembly and poleshoe.

When installing the coil assembly, be sure the coil assembly is in the original position in the frame. If it is not the coil leads cannot be properly connected. Insert the poleshoe into the coil, be sure the poleshoe shims are all in place and secure the poleshoe to the frame. Tighten the poleshoe mounting screws securely. Install each of the other coils and poleshoes in the same manner. Connect the external leads as marked on the tags. If a new coil assembly is being installed, make the connections the same as marked for the old coil assembly.

POLESHOE INSTALLATION.- Follow the instructions given for FIELD COIL INSTALLATION.

## CONTROLS

If any of the control equipment fails to function properly replace the defective part with a new part of the same kind rather than try to repair the old part. No attempt should be made to repair such parts as meters, fuses, switches, relays or receptacles. Check all electrical connections and contacts whenever servicing control equipment.

Always disconnect the battery of the Remote Control and Battery Charging plants whenever servicing controls to avoid accidentally starting the plant. When disassembling controls, tag each lead that has to be removed and mark the connection point of the lead on the tag to assure correct connections when reassembling.

| POSSIBLE CAUSE | REMEDY |
|---|---|
| **ENGINE CRANKS TOO STIFFLY** | |
| Too heavy oil in crankcase. | Drain. Refill with lighter oil. See PREPARATION. |
| Engine stuck. | Disassemble and repair. |
| **ENGINE CRANKS TOO SLOWLY WHEN CRANKED ELECTRICALLY** | |
| Discharged or defective battery. | Recharge or replace. |
| Loose connections. | Tighten loose connections. |
| Corroded battery terminals. | Clean corroded terminals. Replace cable if necessary. |
| Brushes worn excessively or making poor contact. | Replace brushes or clean commutator. |
| Short circuit in generator or load circuit. | Repair or replace parts necessary. Disconnect load. |
| Dirty or corroded points in start solenoid switch. | Replace switch. |
| **ENGINE WILL NOT START WHEN CRANKED** | |
| Faulty ignition. | Clean, adjust, or replace breaker points, spark plugs, condenser, etc., or retime ignition. |
| Lack of fuel or faulty carburetion. | Refill the tank. Check the fuel system. Clean, adjust, or replace parts necessary. |
| Clogged fuel filter. | Clean. |
| Cylinders flooded. | Ground spark plug cables. Crank engine with spark plugs removed. |
| Poor fuel. | Drain. Refill with good fuel. |
| Poor compression. | Tighten cylinder heads and spark plugs. If still not corrected, grind the valves. Replace piston rings if necessary. |
| Wrong ignition timing. | Reset breaker points or retime ignition. See IGNITION. |

| POSSIBLE CAUSE | REMEDY |
|---|---|
| **ENGINE RUNS BUT VOLTAGE DOES NOT BUILD UP** | |
| Poor brush contact. | See that brushes seat well on commutator and collector rings, are free in holders, are not worn shorter than 5/8 inch, and have good spring tension. |
| Open circuit, short circuit, or ground in generator. | Refer to the GENERATOR section of Maintenance and Repair. |
| **VOLTAGE UNSTEADY BUT ENGINE NOT MISFIRING** | |
| Speed too low. | Adjust governor to correct speed. |
| Poor commutation or brush contact. | Refinish commutator or undercut mica if necessary. See that brushes seat well on commutator and collector rings, are free in holders, are not worn shorter than 5/8 inch, and have good spring tension. |
| Loose connections. | Tighten connections. |
| Fluctuating load. | Correct any abnormal load condition causing trouble. |
| **GENERATOR OVERHEATING** | |
| Short in load circuit. | Correct short circuit. |
| Generator overloaded. | Reduce the load. |
| Improper brush rig position. | See BRUSHES, Maintenance and Repair. |
| **ENGINE OVERHEATING** | |
| Improper lubrication. | See Low Oil Pressure. |
| Poor ventilation. | Provide ample ventilation at all times. |
| Dirty or oily cooling surfaces. | Keep the engine clean. |
| Retarded ignition timing. | Retime ignition. |
| Generator overloaded. | Reduce load. |
| **VOLTAGE DROPS UNDER HEAVY LOAD** | |
| Engine lacks power. | See remedies under "Engine Misfires At Heavy Load" |

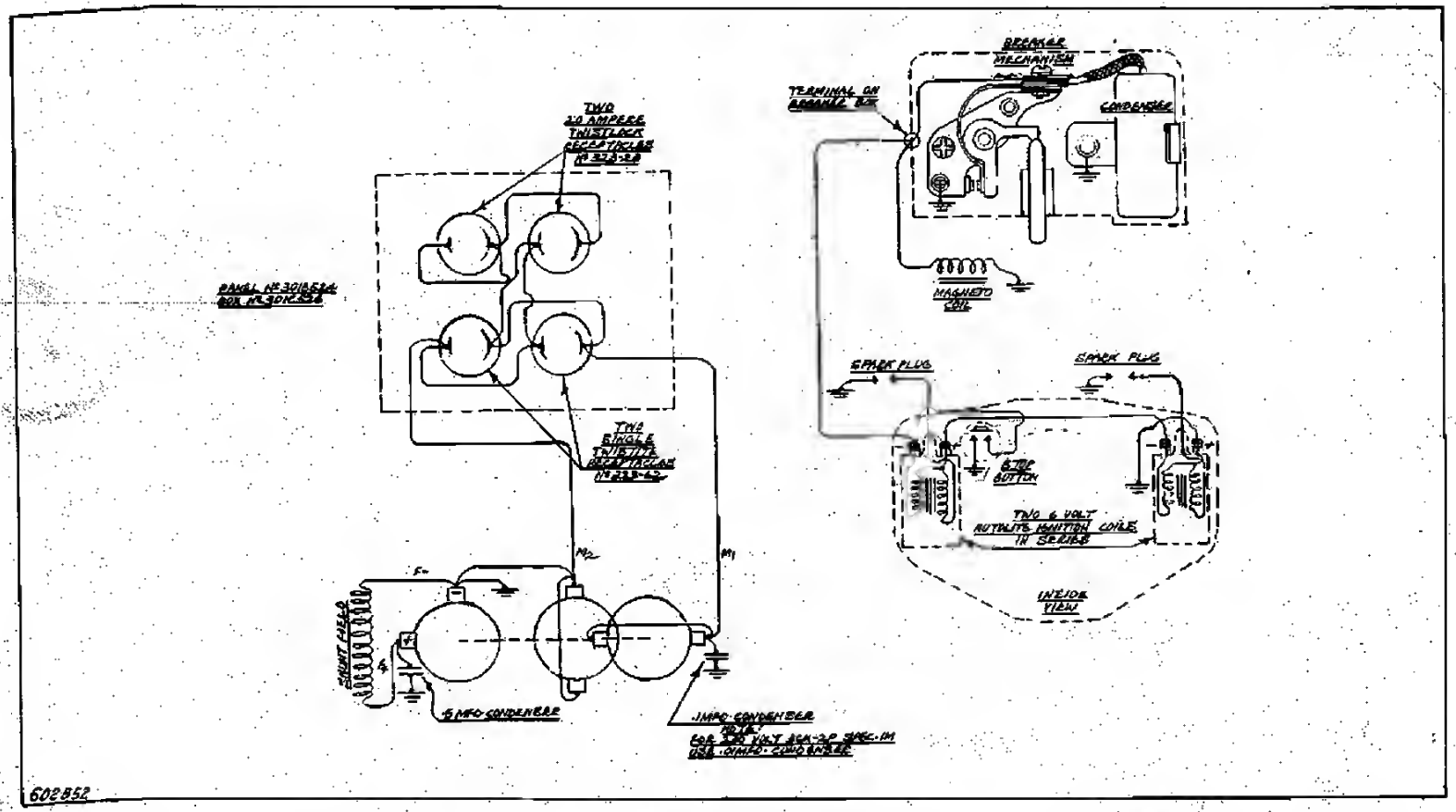
| POSSIBLE CAUSE | REMEDY |
|---|---|
| **VOLTAGE DROPS UNDER HEAVY LOAD (CONT.)** | |
| Poor compression. | Tighten cylinder heads and spark plugs. If still not corrected, grind the valves. Replace piston rings if necessary. |
| Faulty carburetion. | Check the fuel system. Clean, adjust or repair as needed. |
| Dirty carburetor air cleaner. | Clean. Refill with proper oil. |
| Choke. | Choke plate must be wide open at operating temperature. |
| Carbon in cylinders or in carburetor venturi. | Remove carbon. |
| Restricted exhaust line. | Clean or increase the size. |
| **ENGINE MISFIRES AT LIGHT LOAD** | |
| Carburetor idle jet clogged or improperly adjusted. | Clean. See ACCESSORY SERVICE. |
| Spark plug gaps too narrow. | Adjust to correct gap - .025". |
| Intake air leak. | Tighten manifold and carburetor mounting screws. Replace gaskets if necessary. |
| Faulty ignition. | Clean, adjust, or replace breaker points, spark plugs, condenser, etc. |
| Poor compression. | Tighten cylinder heads and spark plugs. If still not corrected, grind the valves. Replace piston rings if necessary. |
| **ENGINE MISFIRES AT HEAVY LOADS** | |
| Defective spark plug. | Replace. |
| Faulty ignition. | Clean, adjust, or replace breaker points, spark plugs, condenser, etc., or retime ignition. |
| Clogged carburetor. | Clean carburetor. |

| POSSIBLE CAUSE | REMEDY |
|---|---|
| **ENGINE MISFIRES AT HEAVY LOAD (CONT.)** | |
| Clogged fuel screen. | Clean. |
| Defective spark plug cable. | Replace. |
| **ENGINE MISFIRES AT ALL LOADS** | |
| Fouled spark plug. | Clean and adjust. |
| Defective or wrong spark plug. | Replace. |
| Leaking valves. | See VALVE SERVICE. |
| Broken valve spring. | Replace. |
| Defective or improperly adjusted breaker points. | Adjust or replace breaker points. |
| **LOW OIL PRESSURE** | |
| Oil too light. | Drain, refill with proper oil. |
| Oil badly diluted. | Drain, refill with proper oil. |
| Oil too low. | Add oil. |
| Oil relief valve not seating. | Remove and clean, or replace. |
| Badly worn bearings. | Replace. |
| Sludge on oil screen. | Remove and clean. |
| Badly worn oil pump. | Replace. |
| Defective oil pressure gauge. | Replace. |
| **HIGH OIL PRESSURE** | |
| Oil too heavy. | Drain, refill with proper oil. |
| Clogged oil passage. | Clean all lines and passages. |
| Oil relief valve stuck. | Remove and clean. |
| Defective oil pressure gauge . | Replace. |

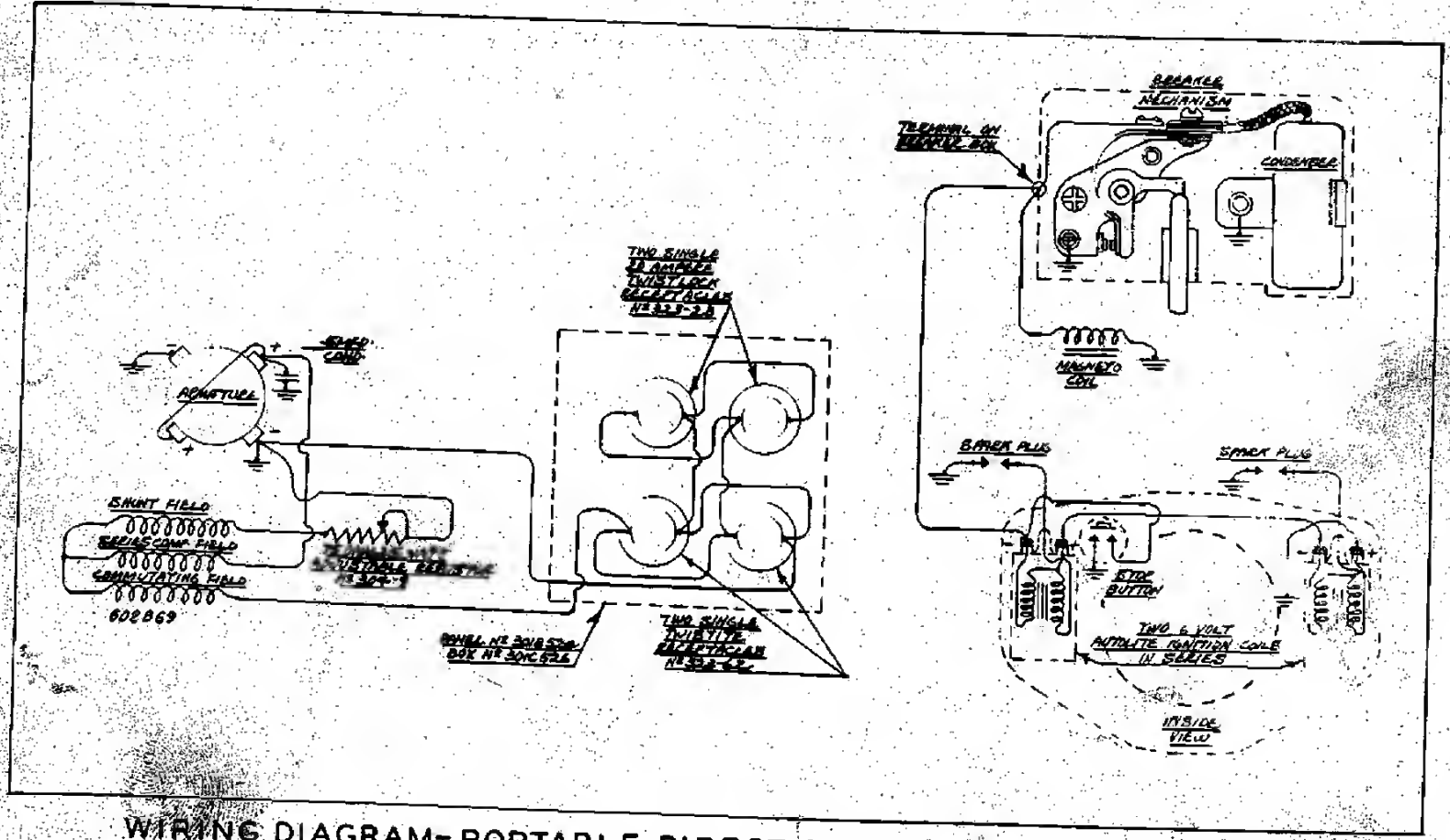
| POSSIBLE CAUSE | REMEDY |
|---|---|
| **ENGINE BACKFIRES AT CARBURETOR** | |
| Lean fuel mixture. | Clean carburetor. Adjust jets. |
| Clogged fuel filter. | Clean. |
| Air leak at intake manifold or carburetor flange. | Tighten mounting screws. Replace gaskets if necessary. |
| Poor fuel. | Refill with good, fresh fuel. See PREPARATION. |
| Spark advanced too far. | Reset breaker points or retime ignition. |
| Intake valve leaking. | Reseat or replace. |
| **EXCESSIVE OIL CONSUMPTION, LIGHT BLUE SMOKY EXHAUST** | |
| Poor compression. Usually due to worn pistons, rings, or cylinders. | Refinish cylinders. Install oversize pistons and rings. |
| Oil too light or diluted. | Drain. Refill with proper oil. |
| Too large bearing clearance. | Replace bearings necessary. |
| Engine misfires. | Refer to "Engine Misfires At All Speeds". |
| Faulty ignition. | Clean, adjust, or replace breaker points, spark plugs, condenser, etc., or retime the ignition. |
| Too much oil. | Drain excess oil. |
| **BLACK, SMOKY EXHAUST, EXCESSIVE FUEL CONSUMPTION, FOULING OF SPARK PLUGS WITH BLACK SOOT, POSSIBLE LACK OF POWER UNDER HEAVY LOAD.** | |
| Fuel mixture too rich. | See that choke opens properly. Adjust jets properly. Adjust the float level. |
| Choke not fully open. | See that choke opens properly. |
| Dirty air cleaner. | Clean. Refill with proper oil. |

| POSSIBLE CAUSE | REMEDY |
|---|---|
| **LIGHT POUNDING KNOCK** | |
| Loose connecting rod. | Adjust clearance or replace. |
| Low oil supply. | Add oil. Change if necessary. |
| Oil badly diluted. | Drain. Refill with proper oil. |
| Low oil pressure. | See Low Oil Pressure for remedies. |
| **ENGINE STOPS UNEXPECTEDLY** | |
| Empty fuel tank. | Refill. |
| Defective ignition system. | Check the ignition system. Repair or replace as needed. See that the STOP button lead is not grounded. |
| **DULL METALLIC THUD, IF NOT BAD, MAY DISAPPEAR AFTER FEW MINUTES OPERATION, IF BAD, INCREASES WITH LOAD.** | |
| Loose crankshaft bearing. | Replace, unless one of the next two remedies permanently corrects the trouble. |
| **SHARP METALLIC THUD, ESPECIALLY WHEN COLD ENGINE FIRST STARTED** | |
| Low oil supply. | Add oil. Change if necessary. |
| Oil badly diluted. | Drain. Refill with proper oil. |
| **PINGING SOUND WHEN ENGINE IS SUDDENLY OR HEAVILY LOADED** | |
| Carbon in cylinders. | Remove the carbon. |
| Spark advanced too far. | Reset breaker points or retime ignition. |
| Wrong spark plugs. | Install correct spark plugs. Champion H9 Com. |
| Spark plugs burned or carboned. | Clean. Install new plugs if necessary. |
| Valves hot. | Adjust tappet clearance. See VALVE SERVICE. |
| Fuel stale or low octane. | Use good, fresh fuel. See PREPARATION. |
| Lean fuel mixture. | Clean fuel system. Adjust carburetor jets properly. |

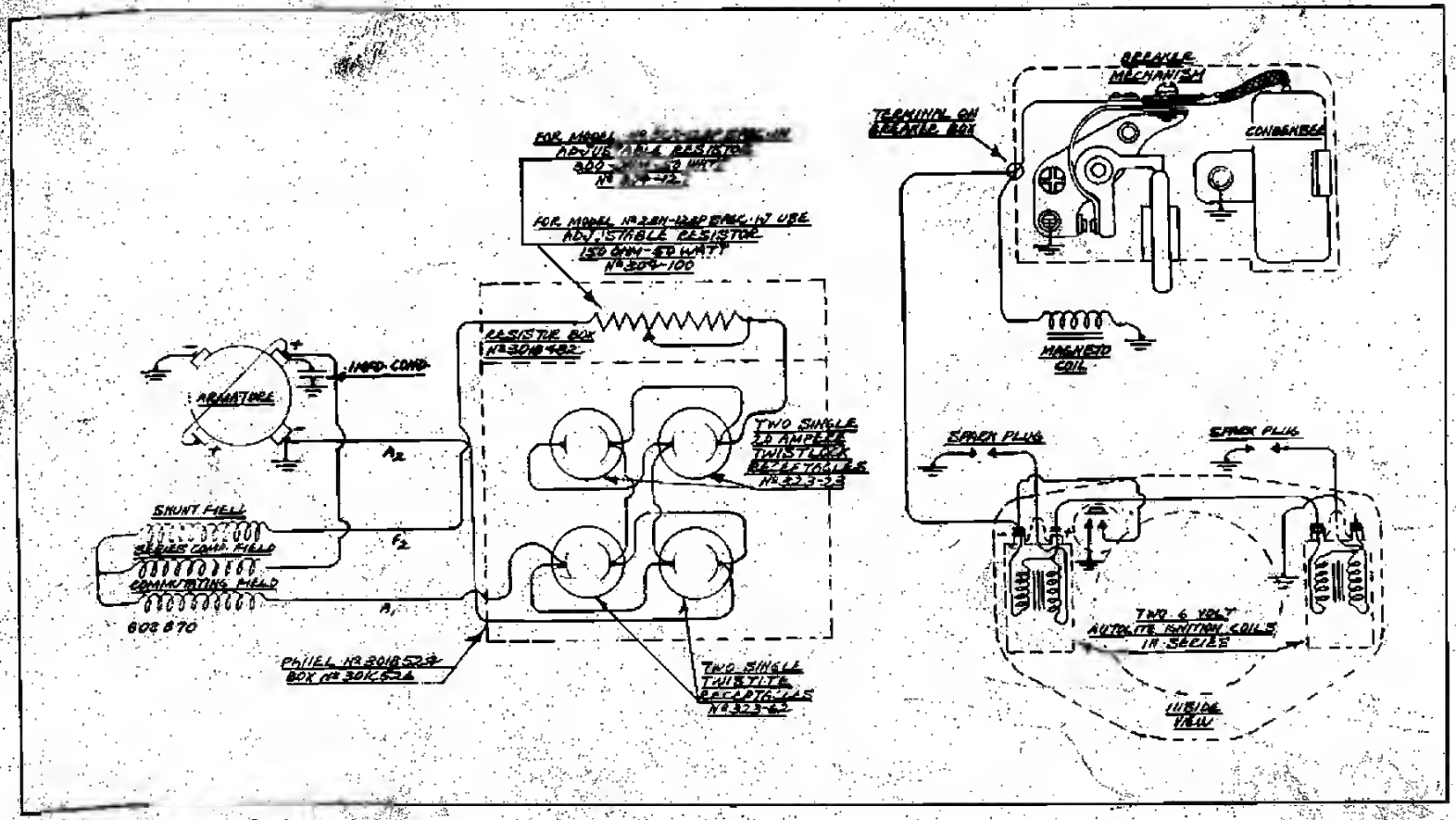
| POSSIBLE CAUSE | REMEDY |
|---|---|
| **TAPPING SOUND** | |
| Valve clearance too great. | Adjust to proper clearance. See VALVE SERVICE. |
| Broken valve spring. | Install new spring. |
| **HOLLOW CLICKING SOUND WITH COOL ENGINE UNDER LOAD** | |
| Loose piston. | If noise is only slight and disappears when engine warms up, no immediate attention needed. Otherwise replace parts necessary. |
| **VOLTAGE LOW AT FAR END OF LINE BUT NORMAL NEAR PLANT** | |
| Too small line wire used for load and distance. | Install larger or extra wires or reduce load. |
| **MOTORS RUN TOO SLOWLY AND OVERHEAT AT FAR END OF LINE BUT OK NEAR PLANT.** | |
| Too small line wire used for load and distance. | Install larger or extra wires or reduce load. |
| **NOISY BRUSHES** | |
| High mica between bars of commutator. | Undercut mica. |
| **EXCESSIVE ARCING OF BRUSHES** | |
| Rough commutator or rings. | Turn down. |
| Dirty commutator or rings. | Clean. |
| Brushes not seating properly. | Sand to a good seat or reduce load until worn in. |
| Open circuit in armature. | Install a new armature. |
| Brush rig out of position. | Line up properly. |



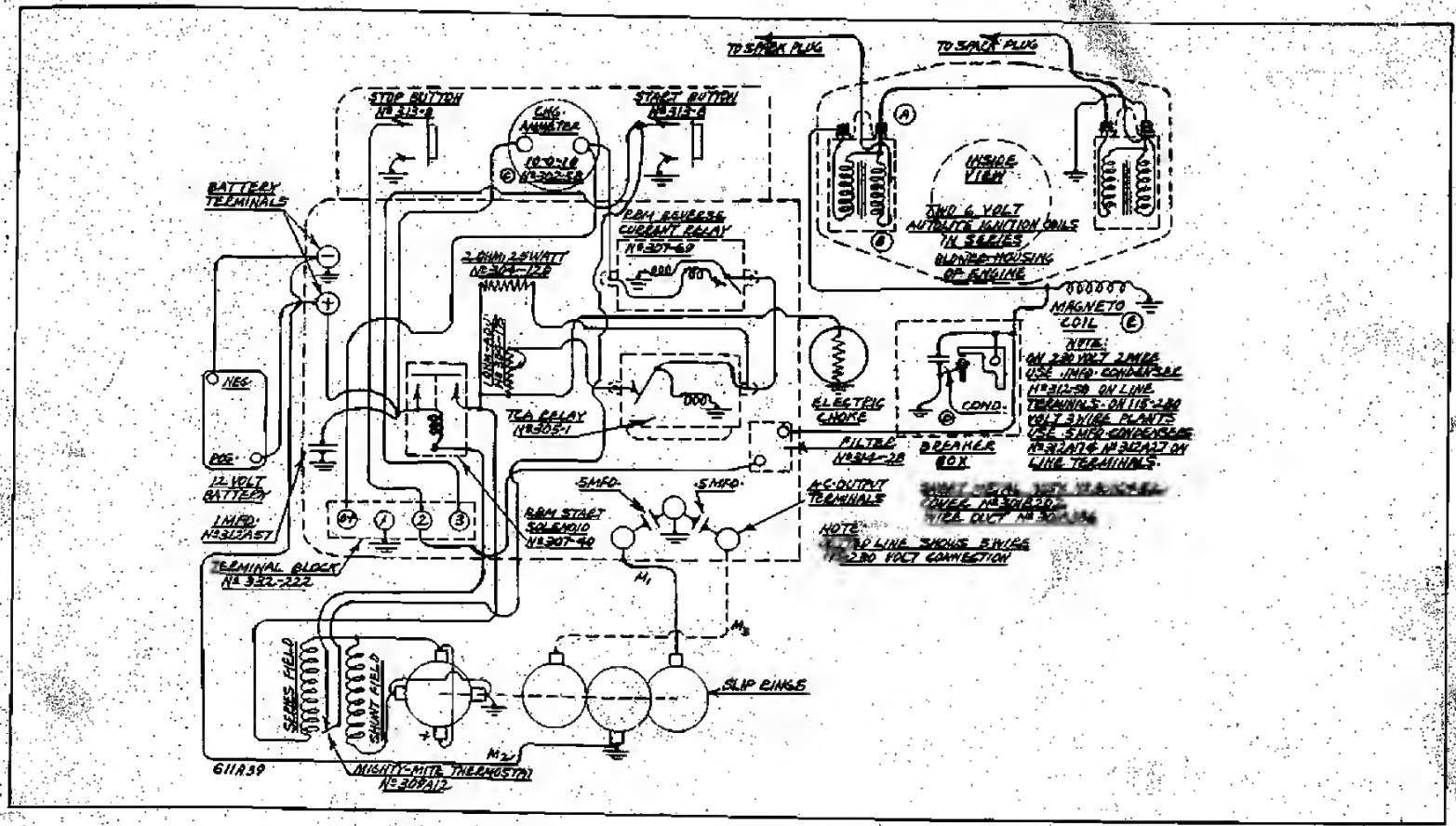

WIRING DIAGRAM-PORTABLE MANUAL START PLANT-115 & 230 VOLT A.C.



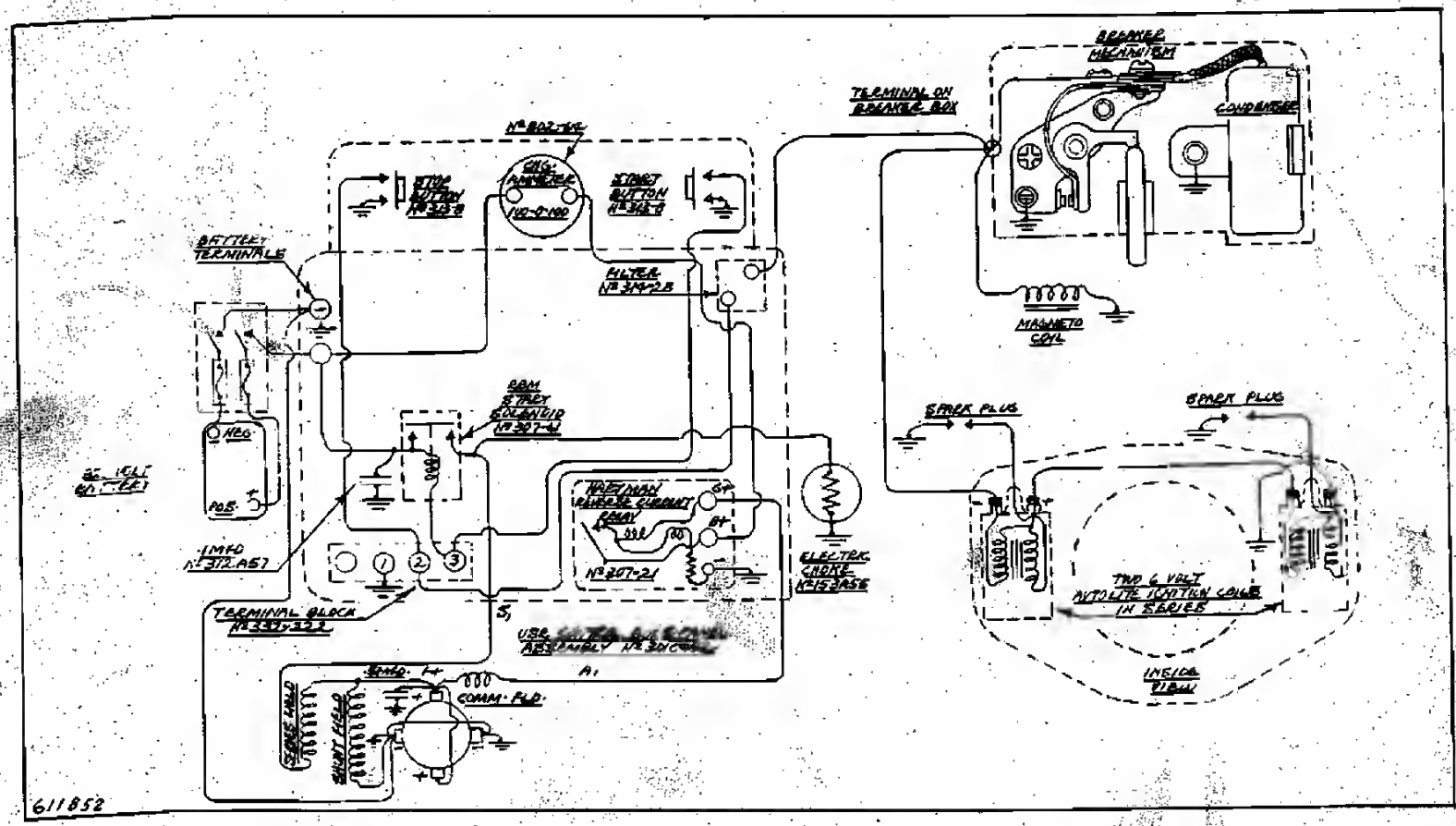

WIRING DIAGRAM- PORTABLE DIRECT SERVICE PLANT-115 VOLT D.C




WIRING DIAGRAM-PORTABLE DIRECT SERVICE PLANT-230 VOLT D.C.




WIRING DIAGRAM- REMOTE CONTROL PLANT




WIRING DIAGRAM - BATTERY CHARGING PLANT